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PLANT AND MATERIAL OF THE PANAMA CANAL.*

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THE engineering world has been presented from time to time during the last eight years with accounts of the financial conditions and probable completion of the Panama Canal. These accounts have been in a large measure circulated in America for a desired effect by friends of the Canal Company, while other reports prejudicial to the company have arisen from employes returning to this country out of health, or from disappointed contractors.

While on the Isthmus in the spring of 1888, I was afforded an excellent opportunity of making a thorough investigation of the whole work, and I think it interesting enough to American engineers to describe the methods of work and the plant and machinery employed in accomplishing the largest task of modern times.

A number of accounts of this work have been given by persons who gained their ideas from the windows of a passing railway train and by hurried visits here and there to the different sections contiguous to the line of the Panama Railroad. This is so unsatisfactory a manner to see all systems of work, that I determined to go over the entire route, commencing at Colon, by steam launch up the canal 15 kilometers, which portion is dredged 15 feet in depth, and then continuing the journey on different days by foot and horseback until I reached La Boca, the Panama end of the line.

In five weeks I traveled over the axial line of canal from Aspinwall to Panama, making a slow and careful examination. In many cases I secured statements from engineers of the Panama Canal Company, engineers of contractors, contractors, foremen, and intelligent workmen, and in order to base an accurate opinion, I have seen all plant individually. It might be well to state that an American engineer need not go to Panama to learn how to execute effective and economical work, and it was most gratifying to contrast the expensive, slow, and cumbersome methods employed by the French contractors with the lighter, more rapid, and economical plant of American manufacture used by contractors in the United States.

All plant on the Panama Canal is owned by the Canal Company, being leased to the different contractors along the line for 8 per cent. a year on the value of the machinery. This system has been expensive to

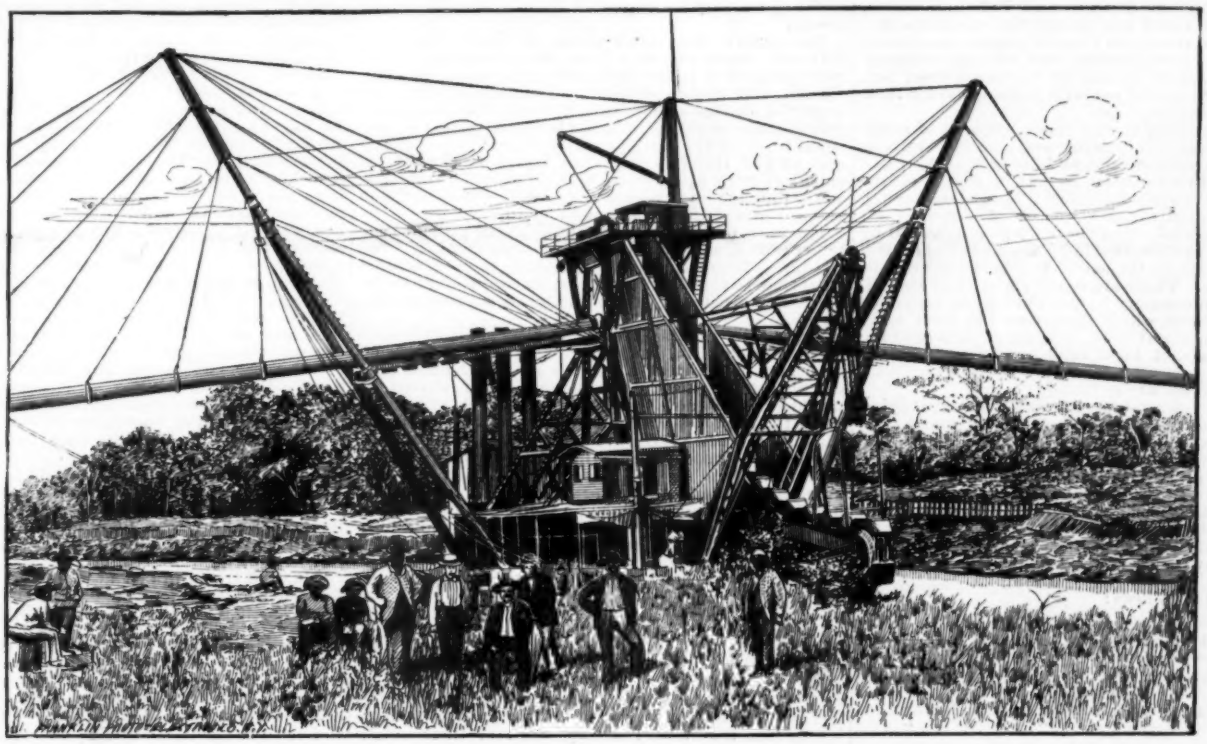


FIG. 1.—AMERICAN "HERCULES" DREDGE CITY OF PARIS.

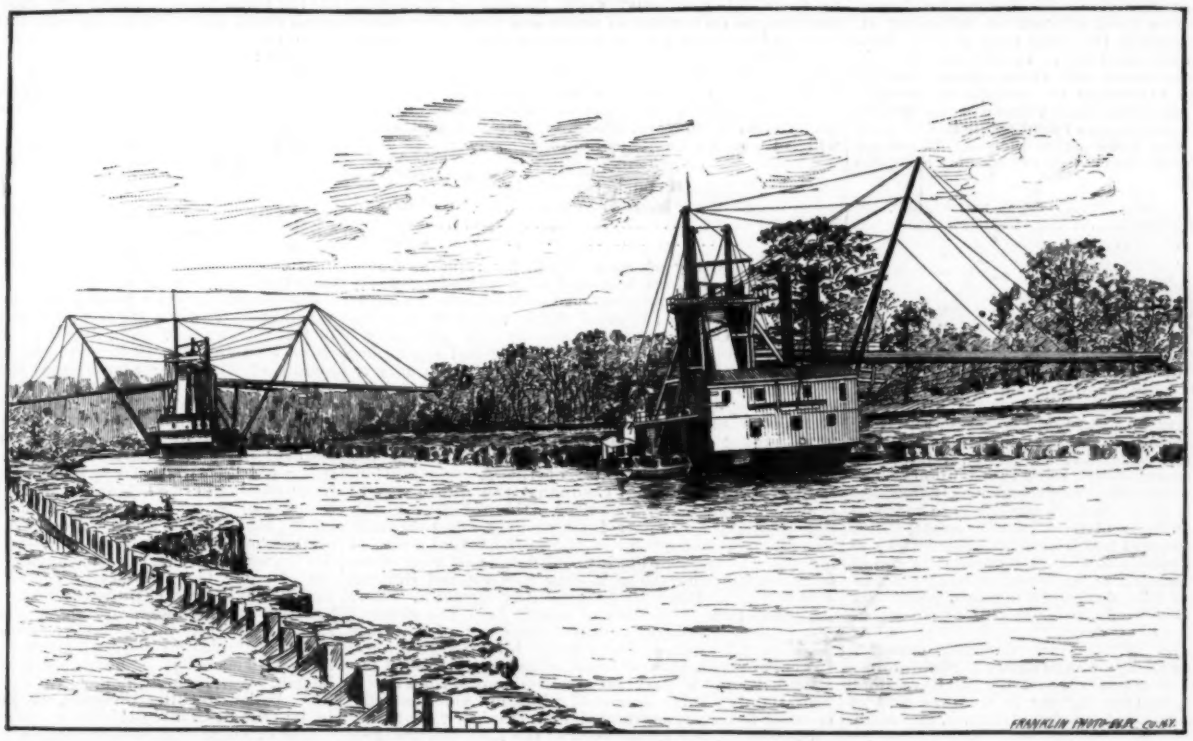


FIG. 2.—AMERICAN "HERCULES" DREDGE WORKING EIGHT METERS ABOVE SEA LEVEL.

* A paper read before the American Society of Civil Engineers, July 2, 1888. From the *Transactions* of the Society.

the company, as contractors not owning the machines would work them daily up to their maximum capacity, spending little or no time in repairs of minor working parts. These machines, from this want of care, would soon break down, and would be side-tracked, the contractor making a requisition for a new machine to continue the work. I saw hundreds of expensive excavators, rock drills, cranes, locomotives, and hoisting engines side-tracked and condemned, only lacking a casting here and there to place the machine in working condition, but through negligence of the workmen rendered useless.

The atmosphere of the whole work is indicative of extravagance, the contractor regarding the Canal Company as a bank of inexhaustible supply, to be drawn upon at all times, and in some cases the claims for demurrages, breakages, and losses made by the contractor are unfair, but are paid even though resulting in large loss to the Canal Company. In short, the climate is deadly, the contractor taking his life in his own hands when he goes there, and it is a question of making the largest amount of money in the shortest possible time in order to leave the country and enjoy the profits in a more healthful climate.

During the primary stages of the work, the Canal Company placed orders for plant with the different foundries throughout France and Belgium, which, being overtaxed, could not supply the machines fast enough. Consequently the Canal Company made contracts with the several firms on the Isthmus to supply their own plant, to be bought by the Canal Company, paying the contractors 15 per cent. commission for their trouble.

This will account for the enormous amount of material on hand, such as hoisting engines, locomotives, cranes, dump cars, steel rails, and dredges. This plant was purchased in quantities largely in excess of the amount necessary for constructing a sea-level canal, the contractors profiting by the excess of orders in their commissions; but now that the work is diminished by adopting a lock system, this large amount of plant will rapidly deteriorate by the action of the climate and be rendered useless. There are many varieties of the different kinds of machinery in use, but I have restricted my mention to those which have done the most satisfactory and economical work, in some cases describing plant which has not been intelligently used by the contractors.

The dredges in use are as follows:

American Hercules dredges, French dredges, Belgian dredges, and *Scotch dredges.*

The American Hercules type (Figs. 1 and 2) is operated by the American Contracting and Dredging Co., of New York, and their work all along the line on the Aspinwall side of the canal shows for itself as an evidence of what American contractors can accomplish in a tropical climate by their great activity and energy. I might also state that they are the only firm of contractors who have successfully carried out their work on time.

Their plant is as follows:

1.	Count de Lesseps, low tower...	All wood.
2.	Nathan Appleton, " ...	"
3.	M. A. Slaven, " ...	"
4.	H. B. Slaven, " ...	"
5.	Dingler, high tower.....	"
6.	City of Paris, high iron tower.	Wooden hull.
7.	City of New York, " "	" "

I find that this company has done good work by employing intelligent and skilled labor, mostly American, Irish, and Swedish, housing and feeding their complement of men, and by attention to their welfare. The organization has been thorough, and the bonus system, by which the captain and crew of the dredge are paid a certain amount of money *pro rata* for having exceeded the average amount of work in any month, instills a high degree of ambition among the force. As to the amount of work done by the dredges I will mention the City of New York, at work at kilometer 14, deepening the channel of the canal from 15 feet. This machine was running nineteen to twenty-one buckets per minute, three-fourths full, three buckets to the cubic meter. The expansion of material in buckets was 30 per cent., occupying more volume in the buckets than in bank. I estimated in twenty-four hours' work it would accomplish 4,800 cubic meters. There are from forty-five to fifty-five men on these machines, distributed as follows:

1 Captain	$300	per month.
3 Assistant engineers	150	"
3 Firemen	70	"
3 Oilers	50	"
3 Diggers	65	"
3 Gypsymen	65	"
1 Steward and three cooks	75	"
6 Waiter boys	30	"
Seamen	50	"

These men are divided into three watches of eight hours each, the machines working night and day, only stopping to repair machinery. Sunday is usually occupied in replacing any worn-out material, replacing links, and anticipating any breakages in upper tumbler bars, boiler tubes, spud gear, etc. From reliable records I find the average work to be relied upon is 100,000 cubic yards per month. The Dingler has excavated 237,000 cubic yards in one month, but it was in redredging material which had slid back into the canal, which was well lubricated and free from such obstructions as stumps and coral rock, allowing the machine to run at a higher speed, fearing nothing from disabling machinery or stoppages of flow of material through pipes from obstructions. I also find that the vibrations of the chain of buckets and links is reduced to a minimum when excavating in material not tenacious, allowing buckets to revolve twenty-five to thirty per minute.

The dredges of iron-tower construction have done satisfactory work, and are lighter in tonnage and of less draught than those of wooden structure, and much more stiff.

The first wooden dredges sent down to the Isthmus were not of the best quality. The Appleton was built in Philadelphia, and has done good work and been subjected to strains of rock and coral dredging, but her tower and hull are giving way more than is warranted had proper material been originally used. The tower being subject to the maximum strains, it was deemed advisable to build a machine with an iron tower, and in the City of New York and City of Paris I find a most admirable style of construction, the machinery running more smoothly and with less vibration than in the wooden tower.

In the wooden towers packing pieces have been resorted to in order to build up solidly all spaces in the upper tower where shafting causes heavy strains and vibrations. Although perfect in work at first, yet from the elasticity of the wood and through friction the joints increased in size and the whole packing became loosened.

In order to gain the immense strength necessary at so great height, 75 feet from the deck, the timbers are of large size, which increases the original cost and increases the tonnage proportionately. Sampson posts, bracing timbers, and packing pieces must be used as stiffeners.

In the iron towers less total weight of material is used, reducing depth of flotation. The tower must be built to resist the strain of belt, producing a pulling strain from forward tending aft, and also the thrust of ladder, resolved into a horizontal thrust at tower and also tending aft.

Thus these strains are all in the same direction and transmitted from strong tower to keelsons and distributed throughout the hull. The method of raising and lowering the ladder and the raising and lowering of the spuds may be improved by adopting hydraulic means.

The spuds used as an axis upon which the dredge revolves are more effective than the control of movements of dredge by fore and aft guys, as in Belgian, French, and Scotch dredges, as rigidly holding the center of dredge and allowing revolution through a true arc, obviating the ridges which are caused by unequal work on the furrows in the other systems. The cost of the Hercules type has varied in the several machines from $100,000 to $120,000 complete at New York, tonnage on first machines being $5,000 to Colon and as low as $3,250 on the last machine.

The same dredges could be built at the present time 15 per cent. cheaper and in a first-class manner. The Dredging Company have improved their machines from time to time, and even now, in the event of building a new dredge, could embody valuable improvements.

I might say that the type of endless-chain-of-bucket dredges has been in use many years, and the Hercules type may be built at a royalty of $5,000 upon each machine, to be paid to the holders of the patent. I would especially note the importance of this type, as in using the high tower and long pipe of discharge, the capacity of work of the dredge is independent of the elements or human work other than on board of the machine.

In other systems emptying into clapets or discharging through pipes supported on pontoons, unavoidable delays arise from non-unity of action, delays in dumping clapets, and serious and unavoidable delays where a number of details of work must be successfully carried out to aid the performance of work of the parent machine.

With the Hercules type this is illustrated, as night and day the machine is worked, the captain having a complete control of his machine and not being dependent on crews of men not under his supervision. This is also forcibly illustrated in visiting Belgian, Scotch, and French dredges, machines capable of doing fair work, yet handicapped by minor details of superintendence and unsatisfactory work of their auxiliaries.

The Hercules type consumes about ten tons of coal per day, and this item is a large one, considering the cost of transportation and transshipment of coal, and I would recommend, in future machines, that patent bridge walls and improved boiler construction be examined with reference to using less coal by more economical combustion of fuel.

The buckets of the Hercules are a serious objection to their doing effective work in clay or tenacious material, as, on account of prismoidal form, they afford means of material adhering to the corners and bottom of bucket.

I made visits to the Dingler, Appleton, M. A. Slaven, H. B. Slaven, City of New York, and City of Paris, timing all work, noting quality of excavation in soft, sticky clay, hard clay, dredging material, and sand, which I would estimate as follows:

	Cubic Yards per day.
Soft, sticky clay, buckets not fully emptying at upper tumbler.....	3,000 to 4,000
Hard clay..	4,000
Sand	5,000

Allowing one day of each week for repairs of machinery, and all days regarded as twenty-four working hours. The estimate of cost of work must embrace the following items: Cost of dredge, towage and insurance to Colon; cost of erection and placing all machinery in working order; building and equipping a machine shop; supplying duplicate machinery at short notice in case of breakage; maintenance of crew; hospital service; cost of New York office and Colon office; erecting fence on banks to prevent sliding of material back into canal; leveling off tops of banks under discharge pipes when too high. In the first contract of the American Contracting and Dredging Company the price was 35 cents per cubic meter, and from estimates given me by the company's engineer I may safely say that there was fifty per cent. profit in the work at that price. I have made investigation into all details of work done by this company, they having encountered difficult problems, dredging in low, marshy grounds, where sliding of whole surface of marsh into the channel caused many delays, and the dredging of materials seven to eight meters above water level by erecting a system of dams. Their work, although performed satisfactorily, and to the great astonishment of the Frenchmen, is only a fair example of what our American contracting firms can accomplish in a tropical climate.

Practically, the whole work of the Hercules dredge is controlled by one man, who is stationed on the bow of the machine. A system of wheels at his hand connects with the different engines, namely, raising and lowering the lever, controlling the main engine and velocity of revolution of buckets, the gypsy engine working the side guys, the spuds also being raised and lowered by tackles on hoisting drums. The digger may, at a glance, take in the situation, and use his governing wheels accordingly.

Referring to the machine shops at Gatun of the dredging company, I would say they are so constructed as to do ordinary repairs of machinery at the shortest possible notice, and this plant cannot be dwelt upon too strongly, as in a region of no foundries and machine shops, a duplication of the principal parts of machinery should be attended to and complete shops built to supply these parts. The question of time is a most important element, and sending to the States for any supplies should be anticipated before breakage should occur.

The report circulated in New York that the Hercules type of machine could dredge 16,000 cubic yards in one day of twenty-four hours arose as follows:

At Gatun, in sandy and soft clay material, frequent sliding in the material occurred, so that the dredge was obliged to retreat to the rear and redredge the material. Material being soft and well lubricated, was easily attacked, allowing the buckets to revolve with a velocity of twenty-five or thirty per minute, without fear of breaking links by the vibratory movement occasioned by the upper tumbler, a square body going through an angle of 360 degrees.

A word as to the preparation of land for dredges. The first contract for clearing and grubbing of right of way should be rigidly enforced, and all stumps, trees, and obstructions removed from surface of ground, as these materials cause frequent delay in stopping up discharge pipes, although the buckets are powerful enough to disintegrate the mass.

Scotch dredges (Fig. 3) are self-propelling, having steamed out from Scotland to Colon and also to Panama, passing around the Horn. Their boilers are of 200 horse power, and their horizontal engines communicate power to a crank shaft on which is a sprocket wheel. The upper tumbler shaft has also a sprocket wheel, and an endless chain communicates from the lower to the upper shaft, transmitting the motion. In heavy work these teeth break at frequent intervals. The ladder is in one section, requiring large construction of parts to gain the required strength for a long member. If in two sections it might be lighter and require less power to raise and lower. This dredge is more adapted for deep sea work than attacking new banks. It discharges into clapets and is controlled by fore and aft guys and side guys wound on friction drums. Its draught is 7 to 8 feet, and it burns six tons of coal per twelve working hours. I visited three Scotch dredges in the Bay of Panama, but their work in discharging into clapets averaged only 200 yards per hour on account of encountering coral rock. In ordinary work they accomplish 2,000 to 3,000 cubic meters per day of twelve hours.

The French dredge (Figs. 4 and 5) is the principal dredge in use along the line of the Panama Canal. There are different sizes, the one most in use being 100 feet long by 30 feet broad, and having a draught of 7 feet of water. The hulls and entire machine are constructed of iron, in sections, in France, shipped to Colon, and transshipped at different points along the line where they are to be used. The cost is, approximately, $115,000 at Colon, not including cost of erection, which has been an expensive work at Panama, some engineers estimating the cost of erection at thirty-five per cent. on original value. The tower is quite low, the elevation of hopper below upper tumbler being only twenty feet above water level. The ladder is in one section, supported upon axis in tower, and varies in length to the use of dredge in attacking new banks or in deepening channels. The buckets are of iron, wrought in one piece, the links being an integral part of the bucket, which I do not regard as an economical construction, or any stronger than if in a separate piece (the Slaven bucket has links bolted to the flanges on the back, so that in case the link becomes much worn it may be easily replaced by a new link without necessitating loss of bucket, which may be in perfect order). The power is derived from a vertical engine, having three pistons, which act directly upward on a crank shaft, which has a gear wheel at either end, and large balance wheels. These gear wheels connect through two other gear wheels to the upper tumbler shaft, thus giving a positive power, and when the machine is dredging in rock, no slipping occurs, as in a belt connection. The engines are 180 horse power in this sized dredge, and it forms a most powerful machine, so that in attacking hard pan or loose rock it receives such a force as to accomplish its work when buckets and links do not break. In ordinary work in sand, gravel, clay, and loose material, a positive force is not necessary, as in rock work. The large belt from a horizontal engine connecting with a gear attachment fitted with a tightener pulley, increasing or diminishing the tension, has given good satisfaction, and controls the movements, except in rock work.

The dimensions of a French dredge of large type are as follows: Length, 120 feet; breadth, 28 feet; depth, 10 feet; draught, 7 feet; depth of working, 28 feet; sheer fore and aft, 10 inches; rise of deck, 6 inches; height of discharge above water line, 20 feet; height of top tumbler above water line, 26 feet 6 inches; width of bucket well, 5 feet 8 inches; frames, 4 inches by 3 inches by 3/8 inch, 2 feet apart, with reverse angle irons 3 inches by 3 inches by 3/8 inch, in alternate frames; plating of bottom and bilges, near well, 7/16 inch; plating otherwise, 3/8 inch; plating of sides, 6 3/8 inch; plating of well, 3/8 inch; deck beams, bulb iron, 8 inches by 3/8 inch, with double angle irons 2 1/2 inches by 2 1/2 inches by 3/8 inch; floors, 12 inches by 4 inches; angle irons, 3 by 3 by 3/8 inches; length of bucket ladder between centers, 64 feet 6 inches; capacity of buckets, 16 cubic feet; diameter of pins, 2 3/8 inches; high pressure cylinders, 17 inches diameter by 24-inch stroke; low pressure cylinders, 34 inches diameter by 24-inch stroke; air pump, 10 inches diameter by 15-inch stroke; circulating pump, 10 inches diameter by 15-inch stroke; boiler diameter, 10 feet 6 inches; boiler length, 9 feet 6 inches; boiler heating surface 900 square feet; boiler working pressure, 80 pounds per square inch; cost at Colon, $115,000.

One of these machines of large type has done valuable work at the Mindi Cut, near Gatun, on the Panama Canal, in broken rock, stiff clay, and hard pan. The material excavated in buckets is carried up into a hopper, discharged with water, pumped up hydraulically sufficiently to discharge it into self-dumping steam clapets alongside. The capacity of these dredges is variable in the extreme, no one machine having done a large amount of satisfactory work. A fair estimate, where no demurrage occurs from want of sufficient

clapets alongside to allow the dredge to steadily discharge through twelve working hours, is 200 to 250 yards per hour. At La Boca, in Panama Bay, a dredge of this type was running twenty buckets per minute—three buckets per cubic meter when full; these were half filled. Coal consumed was about 10 tons per day, and working a crew of twenty-six men, composed of sixteen sailors at $50 per month and ten men in the engineering department, the cost of maintenance be-

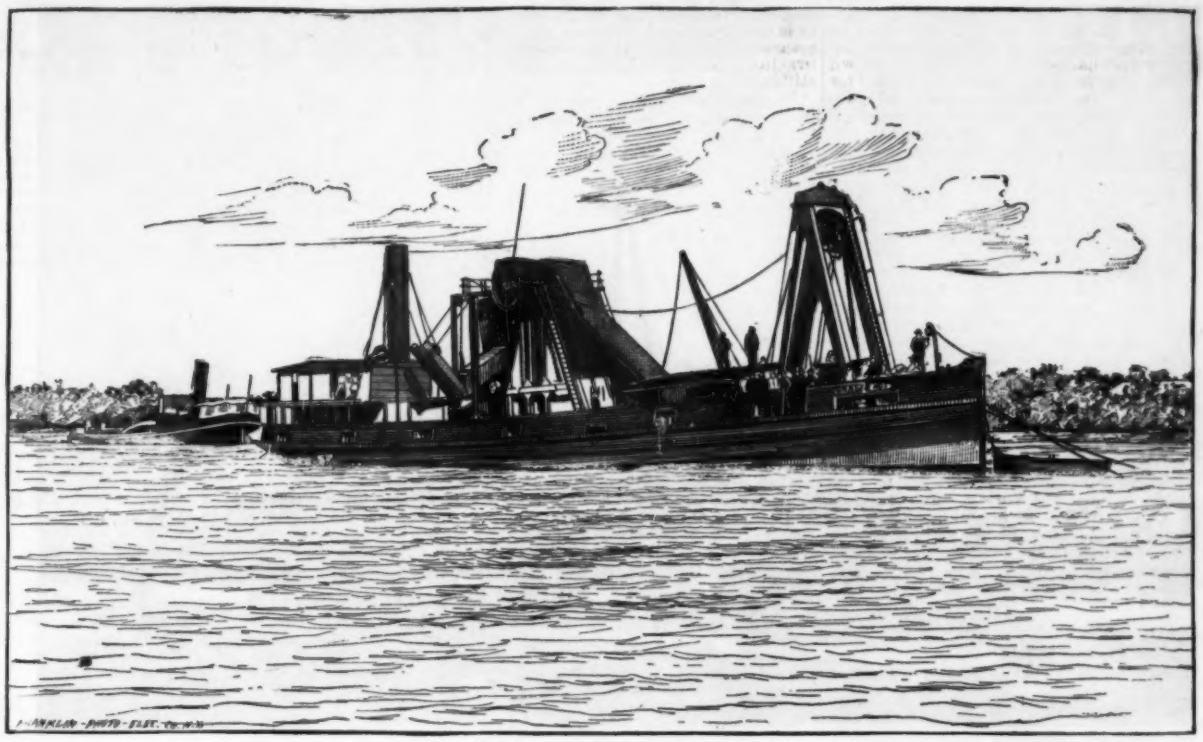


FIG. 3.—SCOTCH DREDGE.

ing $188 per day, excluding breakages. One most important objection to these machines is the number of skilled men necessary to work the machine satisfactorily. The captain or digger stands on the bow of the dredge and takes in the situation, communicating by word his orders to the individual engineers, one in charge of main engine, one in charge of gypsy engine, controlling the side guys, another controls by engine the fore and aft guys, while another engineer controls the ladder, raising or lowering it when necessary. In one case in question these positions were filled by Jamaicans, Colombians, Greeks, and Italians, no two men being of the same degree of intelligence, causing unnecessary delay from loss of time and non-unity of action, while by a system of levers on the bow, connecting with each engine, the digger would be able at a glance to control his machine as completely as an engineer of a locomotive.

I regard these dredges, with this improvement, able to do effective work, and with a high tower and long discharge pipes equal to the Hercules, as their engines are well built, and with good use of power well applied, their ladder and buckets built stiffly, and strains well distributed through tower and hull. The system in all foreign styles of dredges of constructing the ladder in one section is more adapted to deep water dredging than to attacking new banks, while the double ladder of the Hercules type will excavate higher banks with less power applied to raising or lowering the ladder. By the control of the dredge by fore-and-aft guys and by side guys, the work is not as evenly executed as when the dredge revolves upon a central axis or spud, as in a machine digging through an arc of 45 degrees it necessitates the slacking off of both forward and after guys and of one side guy, and "taking up" the other side guy, and as this work is done by several men, and with no absolute precision of action, it is seldom that a dredge is moving to and fro in concentric furrows.

French dredges are also in use where the power is applied through an endless chain fitting over sprocket wheels on the crank shaft and upper tumbler shaft. I find by this system that these teeth break frequently, and it would seem to be most advantageous to use in dredges designed for heavy work a vertical engine connecting directly to gear wheel gearing to upper tumbler shaft. A marked contrast is shown in all machines of foreign construction in being so much heavier in all details than American machines, and in the ladder two sections might have been used, each one having been built lighter and much more stiff than if building it in one section, thus necessitating a ponderous frame to resist buckling of the long length. I submit a record of work of the French dredge at La Boca, April 16.

Character of material, obdurate clay 8 to 10 feet deep.

Clapet No. 5. Capacity 233 cubic meters, filled by dredge 1 hour.

Deducting sixty for amount of water in material and expansion, total 173 cubic meters; and I might add ten to fifteen minutes were lost each time a clapet came alongside, made fast, and dredge commenced working. At Tavernilla, on April 17th, I examined a French dredge at work, attacking a bank 30 feet above water level. This dredge was of 200 horse power, and by undermining the bank, causing it to fall into the bed of the stream, it was able to accomplish its work. The

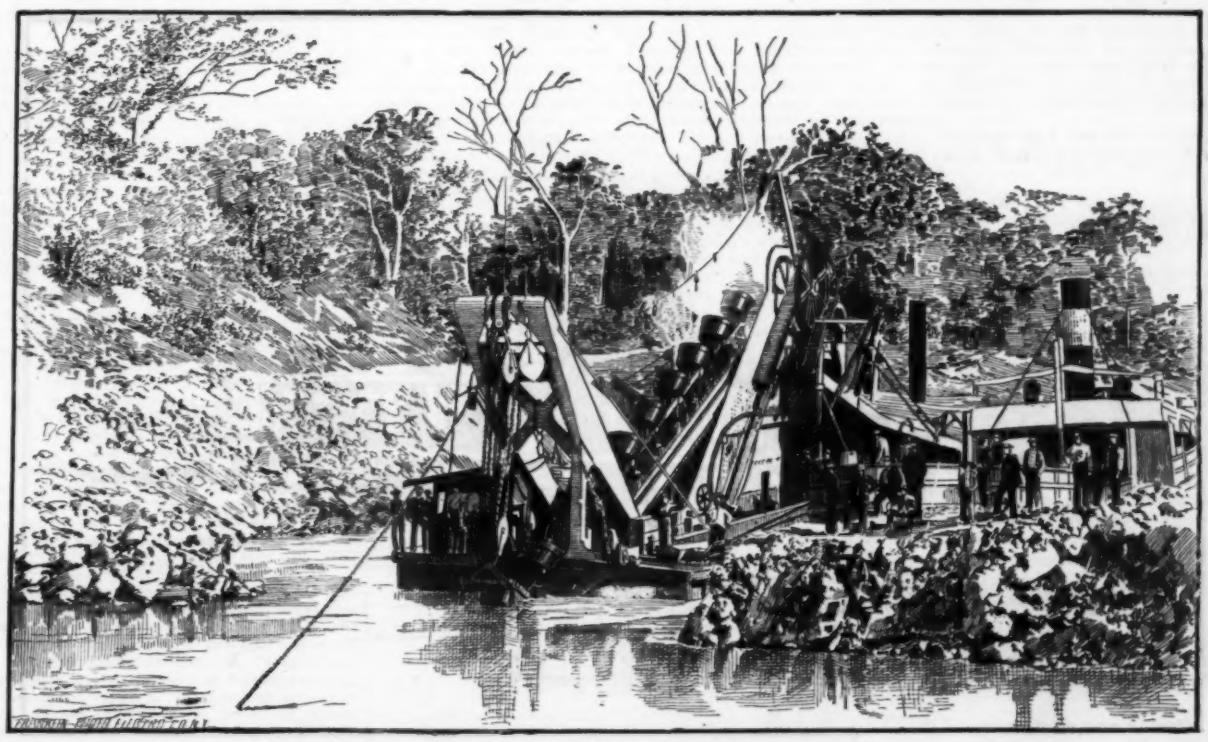


FIG. 4.—FRENCH DREDGE.

Clapet No. 8. Capacity 233 cubic meters, filled by dredge 45 minutes.

Clapet No. 5. Capacity 233 cubic meters, filled by dredge 55 minutes.

Clapet No. 8. Capacity 333 cubic meters, filled by dredge 40 minutes.

method of discharge was hydraulic, as follows: In the neck of the hopper two gratings were securely placed at right angles, making squares 2 inches each way. The material discharged from bucket and falling on to grating was broken up a certain amount by two 8-inch streams of water, pumped hydraulically and directed in their discharge into the hopper to strike the falling material, which became disintegrated when going through the grating. The material then flowed outboard into a closed box at the lower end of the hopper. A scow made fast alongside of the dredge was supplied with boiler and horizontal engine, communicating motion to a centifrugal pump with a 14-inch pipe; a vacuum being formed, the disintegrated and lubricated material in the box at bottom of hopper was taken by suction through the pump, and forced through the corrugated iron discharge pipes, 14 inches in diameter, and supported on pontoons moored in mid-stream; then forced in this case over on to the shore and discharged 90 feet higher than the pump, which was 15 feet above water level, so the elevation of the discharge was 45 feet above water level, and 600 feet distant. They claim to be doing 1,200 cubic meters per day, which was possible when not detained by obstructions. The objection to this system is that by contact of material with blades of pump, oftentimes bolts, snags, stones, and obstructions of all kinds large

enough to go through grating lengthwise would break the blades of the pump. Again, the capacity of dredge running twenty buckets per minute, and discharging material into pipe, in order to work effectively, would require discharge pipe of 20 inches in diameter, instead of 14 inches, as usually 60 to 80 per cent. of diameter of full discharge pipe is water, and the remainder material. The system of pontoons employed for support of pipe was successful. Four cylindrical air-tight boilers

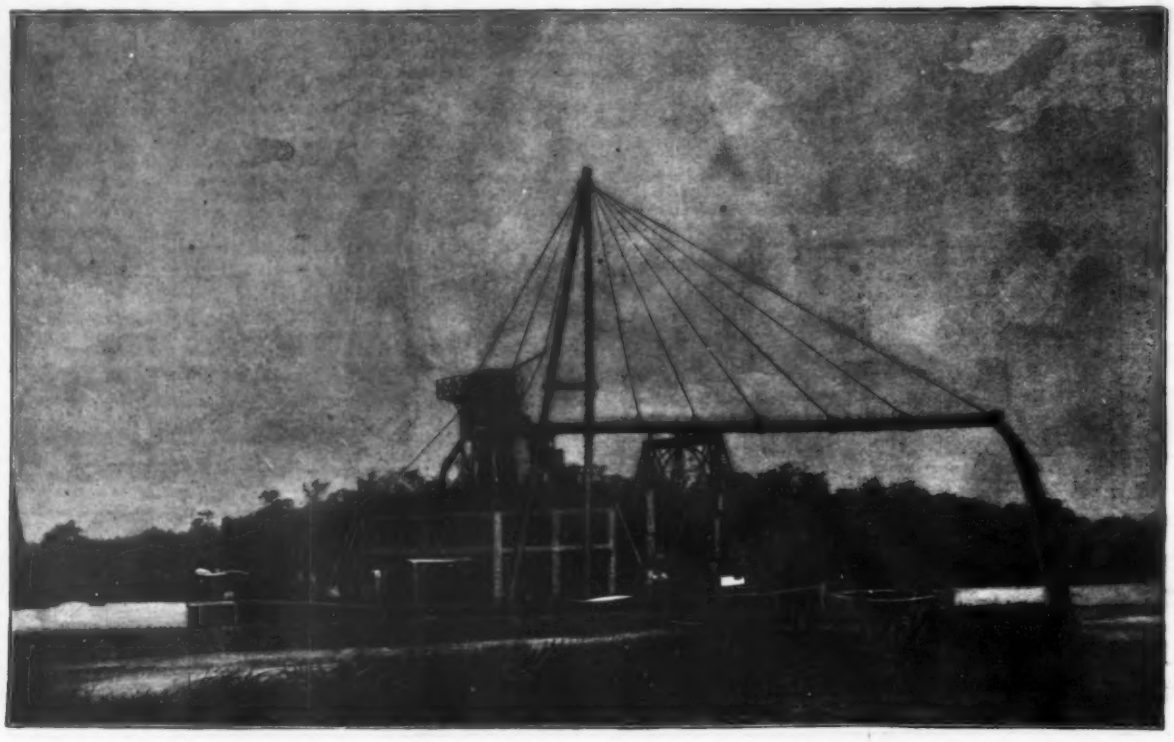


FIG. 5.—FRENCH DREDGE WITH LONG DISCHARGE PIPE.

were constructed of iron, each 5 feet long by 3 feet in diameter. They were floated horizontally in the water and connected rigidly side by side, by wooden braces, and the raft thus formed supported a vertical X brace at each end of the pontoon. The discharge pipe was supported in the Y of the brace. Between the pontoons was a flexible joint 3 feet long, formed as follows: A sleeve of leather was made, the same diameter as pipe; this leather was covered with strong copper wire cloth to make the joint more rigid, and the whole riveted at each end to flange of corrugated iron, of same size as discharging pipe, and this point was made fast as an intermediate, allowing flexibility. This form is not as expensive as ball and socket joint connection, and with leather of sufficient thickness will stand high pressure of 100 to 120 pounds to the square inch.

Where action of dredges is dependent upon discharge through pipes supported upon pontoons, circumstances arise which will seriously impair a regular quantity of work. Pontoons must be controlled with guys, and end of discharge pipe moved from place to place when bank arises from accumulation of discharge material. The discharge pipe must be lengthened or shortened, and transported forward or aft, as the dredge moves forward in her channel of work.

HYDRAULIC DREDGING.—The method of hydraulic discharge in use at Tavernilla I have described, and at the same place I saw in process of construction an auxiliary to the French dredge. An iron barge, 60 feet long by 35 feet broad, contained in the stern three horizontal engines of large type, stroke 3 feet, diameter of piston 20 inches. The piston was elongated and connected direct with cylinder of water pump. The three water pumps received their supply of water from the side of hull, and under high pressure from the cylinder it was forced forward to the hoppers. Amidships in the barge were built two hoppers with large cylinders and a small bottle-necked opening, receiving the discharge of material from the hopper of dredge, the material being well lubricated by water thrown into hopper of dredge through two 9 inch pipes. At the neck of hopper are two iron gratings, placed at right angles over each other, disintegrating the material which falls into the hopper. The outlet is at the bottom of hopper of 20 inches diameter and the entrance pipes for water force are three in number, entering the hopper two at the bottom, and on the quarter opposite the outlet pipe extending the stream to strike the material and drive it toward the outlet; also one pipe entering from above opposite the outlet and inclined in a downward direction; these three streams produced would meet at a radial point, the objective place of outlet of material. This gives the material a great force, depending upon the amount of pressure of the engine, and as the "chute" from the hopper of tower to hopper of barge is a closed pipe and filled with a continually falling mass of earth and water, it practically fills the full diameter of the pipe, making it air tight, so that with any induced pressure at the hopper of the barge, the only outlet of material would be through the bottom of the hopper, then out on shore through pipes located on pontoons. The advantages of this system are as follows: Material does not come into contact with parts of pump, and in extreme cases, when gravel work is to be excavated, the grate bars are removed, thus allowing all material to pass through the hopper when the size of obstruction is not larger than the cross diameter of discharge pipe. In dredging high banks, where the discharge must be made at some distance vertically and horizontally from the dredge, this is the best method in use. Also for harbor work when not affected by swells of ocean or surf, the endless chain of bucket type attacking the material and discharging into hopper and from there floated to the shore by hydraulic discharge may be most expeditiously used. I would recommend that as this plant is quite expensive, the auxiliary barge, costing $20,000, should be constructed separately from the hull of dredge, and may be used with hydraulic or Hercules dredges by proper connections.

In sand dredging the buckets revolved at a speed to fill 15 per cent. of diameter of pipe, the remaining 85 per cent. being filled with water, which must be at higher pressure than for clay work, as each particle of sand sets up for itself, and unless kept moving at a uniform rate will form sand bars in the pipe.

Clay should be disintegrated before going through the discharge pipe, as it forms balls, uniting with sand, gravel or obstacles, and by rolling through pipe, hardens, and I have seen lumps issuing from the pipe of nearly three quarters the diameter, thus blocking up the steady flow of water and material.

BELGIAN DREDGE. (Fig. 6.)—This type of dredge

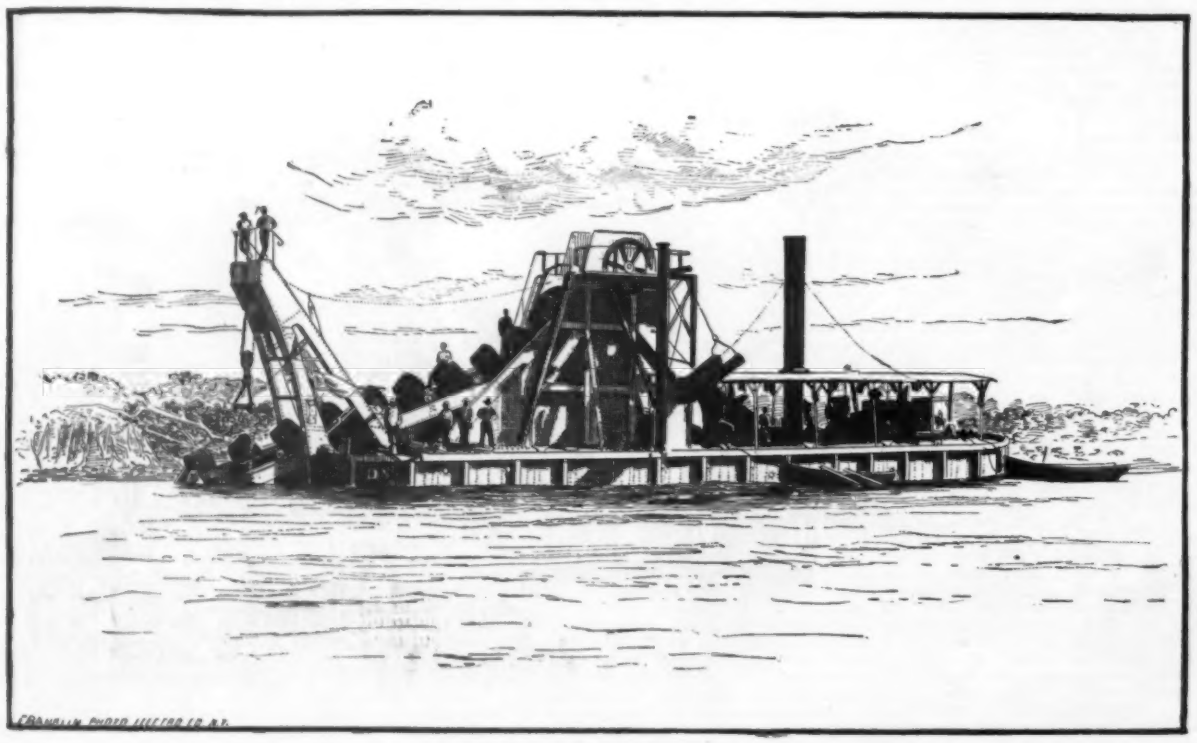


FIG. 6.—BELGIAN DREDGE.

used on the Panama Canal is quite similar to the French dredge, deriving its power in the same manner by sprocket and chain connection. The horse power is two hundred, fitted with three horizontal fire-return tubular boilers and two horizontal engines, whose pistons connect with crank shaft, on which is a wheel.

I find in this system of deriving power that the teeth are constantly breaking. The revolution of the upper tumbler is not with constant velocity, as there are four distinct movements or pulls each time the square upper tumbler goes through the arc of a circle. When the movement is constant, then a toothed wheel and chain connection might be satisfactory, but I do not regard it as such in dredging tenacious material when a positive force more directly applied is necessary. The Belgian dredge discharges on either side into clapets, and the velocity of buckets was from fifteen to twenty per minute, each holding one-third of a cubic meter. I did not see any improvements on the machine other than were embraced on the French dredge. The cost was less than the French dredge on account of less tonnage, and I was informed they could be landed on the Isthmus at $90,000 each; the percentage of construction varying largely, whether they were "set up" at Colon or some miles distant on the line, requiring shops and quarters for men to be erected at an additional expense. The complement of men ran from thirty to forty, and in French, Belgian and Scotch machines were arranged in only one watch, and these dredges only worked during the day, on account of liability of clapets running aground in steaming to and fro from the dumping ground at night, from unsafe pilotage.

(To be continued.)

IMPROVED STEAM INSPECTION CAR.

THE accompanying illustrations show a new and handy steam inspection car. Fig. 1 is a side elevation of the car ready for service. Fig. 2 is a section through the boiler, the construction of which is quite interesting for two reasons: first, because it has a great steam-generating power in proportion to its weight; second, on account of the rapidity with which steam can be raised. The wheels, axles, and car body, as shown in Fig. 1, are not materially different from the ordinary section car, except that each axle is provided with spiral springs above the axle boxes, which slide in jaws in a manner similar to the boxes in passenger car trucks. These springs and sliding boxes are to relieve the jar of the machinery and render the car more comfortable to ride upon. The weight of the car when fully equipped for service, with water tank full of water and a full supply of coal, is about 700 pounds. The weight, with all the steam attachments, is less than twice that of the ordinary section car.

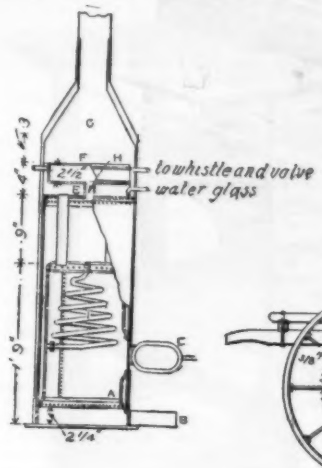


FIG. 2.

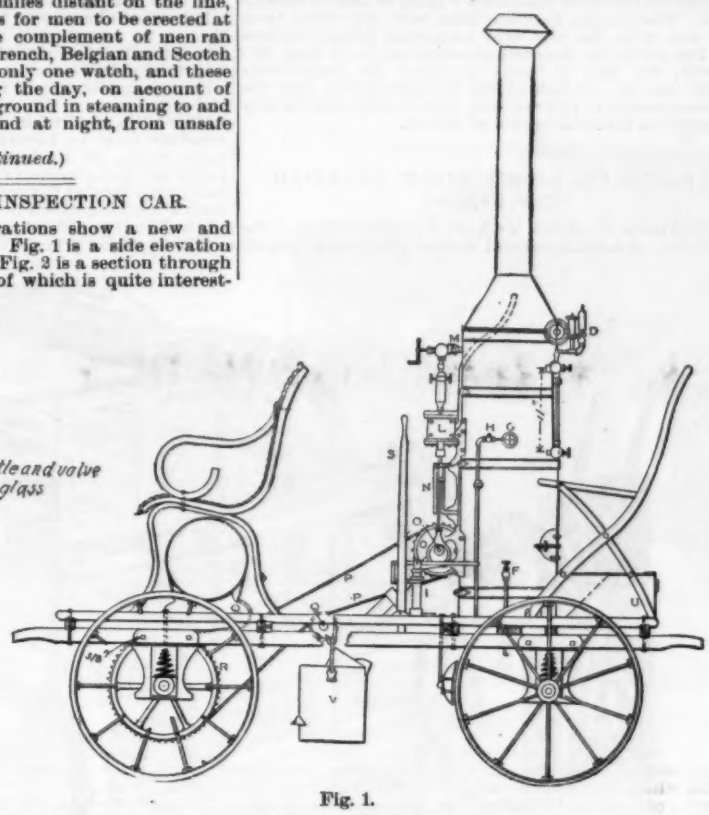


Fig. 1.

THE IONIA STEAM INSPECTION CAR.

The following is a description of the machinery:

A small upright boiler, shown in detail in Fig. 2, is mounted just in front of the rear axle. This boiler is furnished with a smokestack, water glass, whistle, D, steam gauge, blow-off, F, and check valve, G, with intermediate check, H, through which the boiler is fed. A hand pump is placed at I, which takes water from the tank under the passenger seat when desired. The steam cylinder, L, is placed in the center of the car on the front of the boiler. The throttle valve is attached to the boiler at M. The guide and connecting rod are vertical, and are shown at N. The shaft, O, carries the eccentric, and upon it is mounted a sprocket wheel, as shown, around which passes a link belt, shown at P, which also passes over idlers at Q Q, and around a large sprocket wheel on the forward axle, which is used as a driving axle. The idlers take up all slack in the belt. The use of the link belt gives the car greater flexibility than could be had with any other means of transmitting the power. The brakes are applied by means of the lever, S, which is placed within easy reach of the engineer, who sits in the seat placed on the near and left hand side of the car, as shown. The coal supply is carried in the coal tank, U, which holds about one bushel, or sufficient to run the car a distance of fifty miles. The swinging bucket, V, is used for taking water to fill the tank when desired. The seat over the front axle will carry three persons comfortably.

The boiler, shown in Fig. 2, consists of an outer casing 12 in. in diameter, and an inner casing, leaving a water space between. The grate is placed at A, the ashes are drawn out at B, which is the ash pit door. The fire is fed through the fire door, C. The upper and lower tube sheets are apparent in the engraving, the upper one being shown at E. The tubes are six in number, 2 in. in diameter and 9 in. long. A steam dome, F, to which are connected the boiler attachments and throttle valve, is placed in the smoke arch, G. This steam dome is made of a boiler tube with ends brazed in. It is connected in the boiler by 1 in. pipe, shown at H. In order to increase the circulation and the rapidity of steam production, a coil of ⅝ in. copper pipe is placed in the fire box. The lower end of this coil is connected to the water space just above the fire, and the upper end to the center of the lower tube sheet, as shown. The foundation of the boiler consists of a one-eighth iron plate, 15 in. in diameter. The boiler is made of a seamless tube 12 in. in diameter, ¼ in. thick, and 2 ft. 6 in. long. The fire box is made of ⅛ in. steel with one joint, as shown. The tube sheets are of ¼ in. steel. The boiler is covered with asbestos ½ in. thick, and furnished with a Russian iron jacket. The steam pressure carried varies from eighty to one hundred pounds, as desired.

The simplicity of the construction enables any one with ordinary intelligence to operate this car without the assistance of an engineer. It will appear from the dimensions that the factor of safety of the boiler is very high. This car carries water sufficient for a sixteen mile run under average conditions. The water consumed is about one gallon per mile. The tank carries sixteen gallons. Steam pressure can be raised in from ten to twelve minutes, and it only requires that length of time to prepare the car for service.

The difficulties presented when an attempt is made to construct a satisfactory steam section car consist principally in the great weight which results from an attempt to construct the boiler machinery in the ordinary form. This great weight prevents the car from being handled by one man when it becomes necessary to leave the track at intermediate points. This car can be easily handled at highway crossings by one man, and can be removed from or placed on the track at any intermediate point by two men.

This car was designed by Mr. John Doyle, chief road master, and Mr. Timothy Morrissy, of the mechanical department of the Detroit, Lansing and Northern, to meet the requirements of engineers, division superintendents, road masters, bridge superintendents, lumber agents, and wood and tie inspectors, who are compelled to have a close and accurate knowledge of the condition of the permanent way. Such a knowledge is not obtainable by inspection from the rear of a train, or from the heavier class of inspection cars, which are compelled to run on schedule time, and, therefore, unable to stop and make close inspection when desired. In order to increase the safety of this car it is furnished with a powerful lever brake with which a stop can be made within twenty-five or thirty feet, and the car immediately removed from the track.

The success of this car has been assured by trials in actual service on the Detroit, Lansing and Northern, the Grand Rapids and Detroit, and the Saginaw and St. Louis roads during the last year. A test was given for the benefit of observers last week, on a grade of 97 feet to the mile. The small engine propelled the car up this grade at about eleven miles per hour. On a level track, it can easily make twenty miles per hour. The car is made by the Ionia Steam Hand Car Co., Ionia, Mich.—*Railroad Gazette.*

RAPID TRANSIT FOR CHICAGO.

MR. H. A. STOLTENBERG, C.E., says in an article on this subject in the *Street Railway Gazette:* Much has been both said and written regarding what is known as rapid transit, and franchises already given to two companies for the construction of elevated railways cannot but cause the citizens of Chicago to look with anxious eyes for the outcome of these seemingly disinterested efforts for their accommodation and the city's welfare. In view of the immense growth of the city, it is an open question as to whether or not any of the proposed systems of elevated transit are really suitable to fulfill all the requirements that such growth will demand; likewise is it of equal importance who shall conduct enterprises and projects of such importance to the city and pertaining so intimately to the common weal.

History knows of no other city in which almost a million inhabitants have sprung up within a little over half a century from its incorporation; and it is, therefore, but natural that its citizens should point with pride to a growth so unprecedented and, at the same time, use the utmost care in the adoption of any innovation that may, in any way, directly or indirectly, affect the interests of the city proper or its citizens.

As a general rule, past experiences should indicate proper methods for the future, and, for this reason, if for no other, the thought suggests itself that the future growth should be taken into consideration in all undertakings that may affect so seriously the present and future value of property. And, if this is true in the case of individual enterprises, it is evident that even greater care should be taken in coming to a decision as to which of the many methods suggested for elevated transit should be adopted, as any mistakes once made in that direction are exceedingly difficult and sometimes wholly impossible to rectify. Assuming this hypothesis to be correct, we should take into consideration the annual percentage of increase in the city's growth and development, before deciding which method of rapid transit is best adapted for the fulfillment of all requirements, as also the reason for the phenomenally rapid growth of the city in a comparatively short period of time.

The geographical location of the city of Chicago makes it only natural that it should have been selected by the trunk lines of railway as the main distributing point for the great Northwest, and its favorable location on Lake Michigan makes it the natural gate of commerce between the immense wheat fields of the Northwest and the eastern markets.

For these reasons it is but fair to premise that the growth and development of the city is permanent and steady, rather than the effect of a mere temporary boom. Accordingly it will be nearly correct to assume, if only for the sake of argument, that the future development of the city will be in proportion to that in the past, at least until the time comes when all the western States and Territories shall have become thoroughly settled and their resources ready for the eastern markets. If this is so, and allowing that most of the suburbs of Chicago become a part of the city, as their annexation is merely a question of time, the census of the future should be about as follows:

Year.	Population.
1910	2,500,000
1930	4,400,000
1950	6,700,000
1970	9,500,000

It is safe to say, however, that the increase will be much dependent upon the attitude of the administration as regards accommodations for the citizens and their business interests; therefore, it is of the greatest importance that the means of transportation from the business center to the residences within the limits of the future city should be properly and duly considered.

Some form of rapid transit still more rapid than at present accorded is, to-day, demanded, and within a short time will, undoubtedly, become an absolute necessity.

All disadvantages can be obviated by securing elevated roads at such a height that they will permit the passage of vessels beneath them without interruption of the traffic.

The highest point that would have to be reached would be about 130 feet above the high water level of the river, or 120 feet above the level of the streets. (See Fig. 1.)

Very little noise would be apparent from the operation of an elevated railway built at such an altitude, neither would the structure darken the streets. But instead of running the road through the center of the streets, we would suggest that the structure be carried above the roofs of the houses, and across the blocks, although, undoubtedly, no little difficulty would be experienced in securing the right of way. But we know of no other arrangement whereby an elevated railroad

FIG. 1.

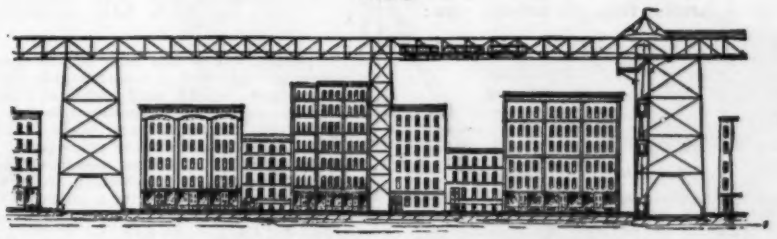


FIG. 2.

that will not obstruct in any way the streets nor interfere with navigation, and that will at the same time transport passengers from the south or north or west sides, can be successfully engineered and operated.

On account of the great danger in case of fire, and because the streets would be too much darkened by the structures, restrictions as to the maximum height of buildings will doubtless be introduced in Chicago in the near future.

The construction of elevated railroads on this principle appears at first wild and fantastic, but on closer examination the objections relative to costs, etc., as well as danger disappear. Although the project has been carefully examined and criticised by several competent engineers, no objections have been set forth as to the practicability of the scheme.

In the northern part of New York City, the elevated roads are built at an altitute nearly suitable for Chicago, owing to the unevenness of the surface; and trains run in this case in straight lines and sharp curves, with the same safety as in the southern part of the city on the regular level. The dangers to which people are subjected who live below such elevated roads are imaginary, as during the thirteen years of existence of the New York elevated roads, not a single serious accident has occurred there.

As the cars would have to run in guiding troughs or between guard rails, the danger of derailing is practically avoided. The noise can be prevented by a proper bedding of the rails, as is done in the case of the Berliner Stadtbahn, in Germany. The danger of fire could be diminished by locating water pipes on the girders.

Of course the construction of a road of this altitude on iron or steel piers, and more especially owing to the longer spans, would be quite expensive, but only in a few cases, if at all, would it be necessary to run the spans in one length over the entire block, as in most instances there would be room for intermediate piers inside the block.

It would not be necessary to run the entire road on the same level, but to provide for a belt line, to be built later on, it should be on this level from north to south between North Avenue and Twenty-second Street, and west to Halsted Street. Further out the height of the road might be lowered, until it reaches that of the ordinary elevated roads, *i. e.*, about twenty feet above the streets.

To obviate the trouble of reaching stations so high up, by tedious stairways, elevators could be constructed in and near the center of the city, in place of the ordinary stairways, which would be out of place where road is run above the usual height, though farther out toward the city limits, and in the suburbs, they would suffice. The additional cost of constructing and running elevators in place of using stairways exclusively would not affect the total cost materially, but, owing to their great convenience, they would considerably increase the volume of traffic.

One elevator would be sufficient for each station, except in the business center, where two or more might be required. The total capacity of fifteen elevators for sixty persons each, on six principal stations inside the business center, making one round trip in 1¼ minutes, would be 36,000 persons per hour. The New York elevated roads carried 115,000,000 passengers during the year 1886, or about 316,000 per day. This shows that a comparatively small number of elevators would be adequate even for New York City.

In the business portion of the city there should be one station to every three or four blocks, while further out one at every section and half section street would suffice. For instance, at Canal and Halsted Streets, and Center and Ashland Avenues, etc.

An elevated road of this description, built as an uninterrupted whole, would enable passengers to travel in every direction unmolested by navigation and without change of car. For instance, from corner North Avenue and Clark Street to South Halsted Street or Garfield Park, and for five cents, as a fare of only five cents for an 11 miles ride is charged in New York. No other elevated road system can offer such advantages!

No figures will be given here relative to the value of elevated roads as a financial enterprise for the present, but if they are at all remunerative, it will surely be better to invest money in roads which have an uninterrupted connection with the business center, than in such which only reach west and north to the river. The loss of time to reach the elevated station of the latter kind, in connection with the bridge trouble and the climbing of stairs, will make them of little value to most people living east of Western Avenue and south of North Avenue, for they can reach their homes or places of business equally soon and more conveniently by the surface road if properly managed. As yet, the city west of Western Avenue and north of North Avenue is not very thickly populated, and, consequently, a disconnected system of elevated roads could not secure a heavy traffic for some years to come. Ordinary elevated roads cannot be built and equipped for less than $500,000 a mile, and those independent of navigation, as proposed, would cost about $900,000 a mile, or 20 miles inside the city limits, $18,000,000.

In New York, during the year 1886, 115,000,000 passengers traveled over the 32·4 miles of double track lines. The gross earnings from this mileage were:

		$7,426,000
As against a gross operating expense of	$3,850,000	
Rentals and taxes	403,000	
		4,253,000
Leaving the net earnings for the year		$3,173,000

At a high estimate the construction of these roads, including rolling stock, did not cost over $700,000 a mile, or the 32·4 miles $22,680,000. The net earnings of $3,173,000, therefore, represent a profit of 14 per cent. of the invested money.

In 1887, the number of passengers increased to 159,000,000, and in 1888 to about 200,000,000, which gives an idea of the enormous rate of increase of traffic, though this phenomenal increase was partly due to the reduction of fare for a few hours of the day.

The successful operation of elevated railroads in the East leaves the final merits of an investment of this kind entirely beyond doubt, as above indicated. Why should not this city of Chicago take a lesson from the eastern cities, and take upon itself the construction and equipment of elevated railways? Only when planned by the administration of the city, with the interests of the public solely in view, can the enterprise be executed in accordance with the demands of the public, and only by persons taking this higher point of view can they be constructed in such a manner that they will prove to be for the best interests of the community at large.

At the same time, the steady increase in the revenue gained thereby would enable the city to meet much larger expenditure in other branches of public improvements.

It has been amply proved by the erection and operation of the water works that the city itself is capable of conducting large enterprises successfully. Not only are consumers of water supplied therewith at a comparatively low rate, but the treasury of the water department has in its possession a fund of nearly $2,000,000. Whereas the gas companies have, for years, been at war with the city, and numerous inconveniences to the public by their mismanagement have been the result, the city of Berlin furnishes its inhabitants with gas at one-half of the Chicago prices, and the management, in spite of this, pays yearly into the city treasury a formidable sum of money.

RAMIE OR RHEEA FIBER CLEANING MACHINERY.

FOR some years past we have at intervals noted the progress of mechanical and chemical science in respect of the production of the fiber of the rheea plant on a commercial scale and in a marketable condition. The great strength, length, and luster of this fiber, qualities which eminently recommend it for use in textile manufactures, have, in fact, made it the subject of solicitous attention for many years past.

The important qualities possessed by this fiber, therefore, render its production in quantity, in an economical manner and in a suitable condition for textile purposes, one of the most important industrial problems of the present day.

For more than thirty years endeavors have been made to utilize this fiber commercially; many thousands of pounds have been spent; the aid of both mechanical and chemical science has been invoked, but almost all in vain, for although this fiber is used to some extent, that extent is extremely circumscribed. Twice during the past eighteen years the Indian government has offered a prize of £5,000 for a machine which should effectually produce the fiber in the required condition, the prize having been twice competed for and twice withdrawn.

The French government recently took up the matter and offered prizes of the value of 6,000 fr. for any process or machine that would produce the fiber in commercial quantities and of proper quality.

The trials of the competing machines were to have taken place last autumn, but we have not heard anything as to their results or even if the trials were carried out.

Our columns have testified during the past five years to the fact that several attempts have been made in this direction, both mechanical and chemical, the various processes having been investigated and reported upon by us.

But promising as these processes were—and some were tried on a fair working scale—they do not appear to have been introduced into general use in a regular, practical way. The great difficulty in the way of success is the satisfactory treatment of the gummy matter in which the fiber is embedded.

It has been found easy to decorticate the rheea stems, that is to remove the fiber, with its adhering bark and cementitious matter, from the wood, but difficult to produce the fiber clean and free from all extraneous adherent matter, ready for the spinner, on a commercial scale.

This holds good with all the varieties of this fiber, whether they be known under the name of China grass, rheea, or ramie; rheea being the Indian and ramie the Malay name of the same plant. At the Irish exhibition held at Olympia last year, however, we met with a machine which promised well for the separation of the fiber from the stems.

This machine is the invention of Mr. John Orr Wallace, of Belfast. This machine was not originally designed for treating rheea fiber, but for flax, and Fig. 1 of our engravings shows it with the buffer alongside as used for flax, the object of the buffer being to dislodge all the woody matter from the flax.

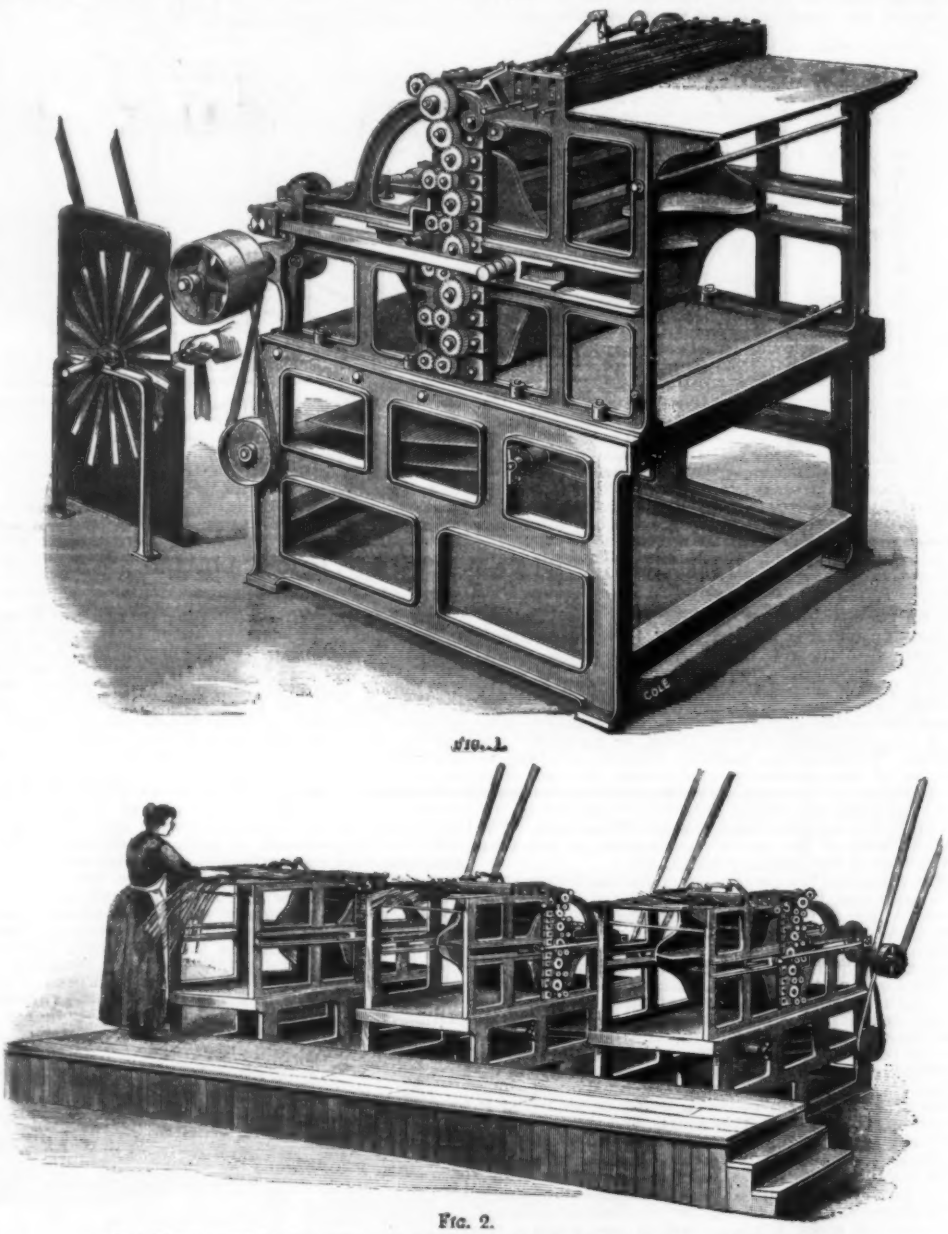


FIG. 2.

RAMIE OR RHEEA FIBER CLEANING MACHINERY.

But notwithstanding that the machine was constructed for another purpose, and was admittedly imperfect as regards its treatment of the rheea plant, we saw the fiber of the latter obtained by it undamaged and fairly free from the woody stem.

The machine in question is a flax scutching machine of novel design, and about 6 feet 6 inches high by 4 feet wide, and 5 feet long over all; is working capacity being put at 1 cwt. of retted flax per hour. It consists of an upper feed table on which the flax straw is fed to three pairs of fluted rollers, which deliver the flax downward between five pairs of pinning tools, alternating with six pairs of guide rollers. The pinning tools somewhat resemble hand hackles, and are attached to two vertical frames, to which a horizontal to and fro motion is imparted, and the pins interlace as the two sides approach. The fibrous material is drawn down-

ward by the rollers, which have an intermittent motion, and at each momentary pause the pricking pins enter the material, and are rapidly withdrawn from it. By degrees this fibrous descending curtain is delivered on to a sloping receiving table at the bottom of the machine, over which table the woody substance has previously passed to a receiver in a crushed and semi-pulverized condition and perfectly free from fiber. Three attendants are required for one machine; but, when large quantities of fiber have to be cleaned, the same attendants are sufficient for three or four of the machines placed alongside each other, as seen at Fig. 2 of our engravings, which represent the machines as arranged for rheea, jute, and hemp, which do not require the buffer.

In moist climates, when rheea has to be worked in its green state, it will be necessary to pass the stems first through another series of rollers to press out the sap before being fed to these machines. Flax straw is much shorter than the ramie and hemp stems, and besides requires a different treatment.

The attendants for one machine for flax are a boy or a girl to prepare straw in bundles, another to feed the straw to the machine, and a man to attend the buffer to clear off the broken woody portions. The two attendants who prepare the bundles and feed the straw can attend to two other machines; but each machine must have a man to buff or clean the flax.

The driving power for each machine is two horse power. Since we saw the machine at the Irish exhibition—and that was the first machine Mr. Wallace made on that pattern—he has applied it to the purpose of preparing jute, for which purpose it appears to be eminently adapted, according to the strong testimony of several leading jute spinners and that of manufacturers of this class of machinery. One important feature of this machine in connection with jute is that it will work the root ends of jute, which, under the ordinary system, have to be cut off, forming a considerable item of waste. The machines are also being put down at a factory in this country for preparing rheea fiber.—*Iron.*

NEW APPARATUS FOR THE CONCENTRATION OF EXTRACTS IN VACUO.

By L. A. ADRIAN.

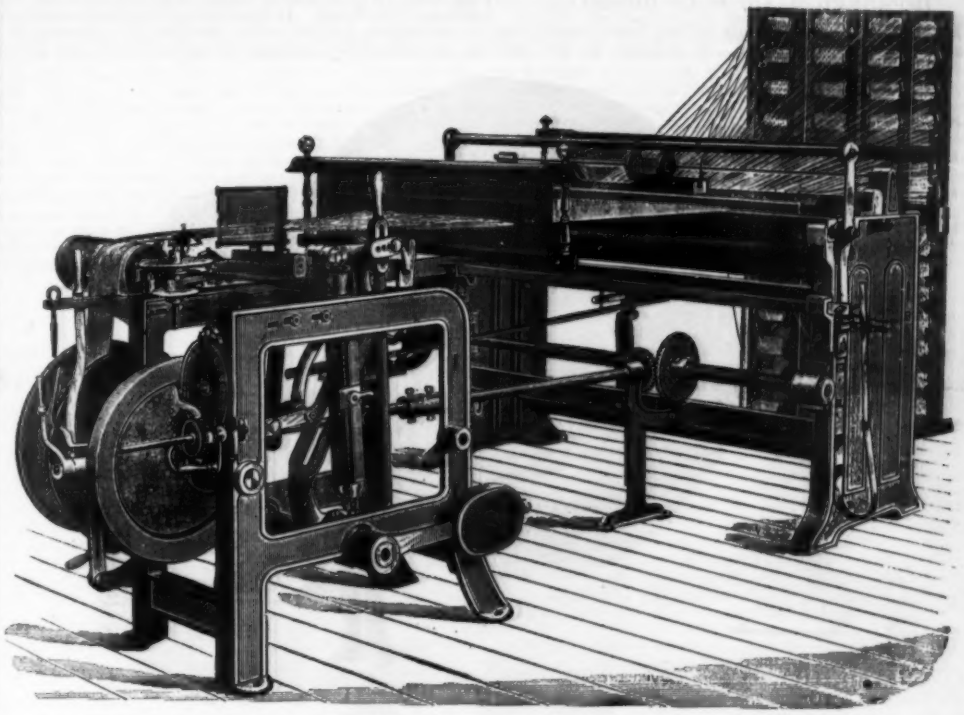
As the result of attempts to avoid the decomposition of the organic substances contained in pharmaceutical extracts by heat and exposure to air during concentration, the author describes the following apparatus, by which the evaporation is effected with a minimum amount of change either in color, taste, or composition. Although the vacuum method has long been employed for the concentration of sugar solutions, the apparatus here described is considerably modified to meet conditions dependent on the nature of the substances under treatment.

The first apparatus, as shown in Fig. 1, was constructed in 1873, and comprises:

A, the vacuum pan, of about 1,000 liters capacity, is cylindrical and terminated above and below by hemispherical steam jackets. B, a cylindrical reservoir, serving as a trap for particles of liquid mechanically carried over during violent ebullition. C, a second reservoir in which the vapors are condensed by a shower of water supplied by the pipe, N. S and U are the connecting pipes conveying the vapors which are drawn over by the vacuum maintained through the pipe, M. N, a tank containing the liquid to be concentrated. G, a pipe conveying steam to the upper jacket. F, a pipe conveying steam after use in the upper jacket to the lower jacket. E, a cock for the introduction of cold water along with the steam to the lower jacket, in which any desired lower temperature may be thus maintained. D, outlet for the hot water or steam. R, sight glass to view the course of the evaporation. T, manhole for removing the finished product.

A vacuum having been established in the apparatus, about 150 kilos. of the liquid are let into A, and the heating is regulated by the several cocks and a thermometer inserted into A. To secure tightness in the vacuum pump, the pistons work under a cushion of water. The evaporator is fed with liquor until about 25 to 30 kilos. of extract are obtained, when it is removed through the manhole preparatory to introducing a fresh charge. The function of the upper steam jacket is simply to prevent condensation of the vapors in the evaporator. This apparatus has served with success in concentrating the mother-liquors of sulphate of quinine, but it presented two principal defects, first, that the curved bottom was unsuitable for a quick and complete removal of the finished product, especially if that were quite dry, and secondly, the absence of any kind of agitation was favorable to the formation of a crust on the surface of the liquid which hindered evaporation and required the application of an undesirably high temperature. The oscillating apparatus shown in Fig. 2 was designed to overcome these defects, and has been in successful operation for two years.

A is an evaporator of tinned copper, with a flat bottom and a capacity of 700 liters, the diameter being equal to four times the height. There are two manholes at opposite sides. The evaporator is double jacketed above and below, D being heated by steam from F, of which the outlet is at G. The pump, V, injects warm water into the lower jacket, and ejects it through the pipe, X, in which a thermometer is placed to register the temperature. The evaporator is hung on an axis, Z, resting on the supports, M N, and an oscillating motion is communicated by a projecting piece from A, carrying a cam which works in an endless groove in the revolving cylinder, Q, geared to a shaft driven by a belt. The dome of the evaporator is connected by an India-rubber pipe, K, to the condensing cylinder, J, containing 400 tubes through which cold water flows. The products of condensation are collected in C, which is in communication with the vacuum pump by the pipe, H. *r* is one of the sight glasses, to view the course of the evaporation, and to regulate the additions of liquid by the pipe dipping into the tank, E. The sides of the evaporator are covered with wood, to hinder condensation within. A charge of 80 liters of liquid is let into the evaporator, and water of 80° into the lower double jacket, steam being let into the upper one. On setting the oscillating movement to work, the evaporating liquid is kept in constant motion, exposing always a fresh surface for evaporation. This condition is very favorable to rapid evaporation and the maintenance of a low temperature, 50 liters of condensed water per hour being easily obtained with a temperature of 35° to 36° C. in the interior of the evaporator, and the desiccation of the residue may be made complete. If the residue be pasty it may be removed through the manhole by tilting the evaporator to one side, and if dry, raked out while still warm.—*Bul. Soc. Chim.*



IMPROVED SECTIONAL WARPING MACHINE.

IMPROVED SECTIONAL WARPING MACHINE.

RECENT experiments have been made by Mr. J. H. Stott, Rochdale, with a result of further improving these machines in the setting and regulating motions, and also, in addition, the value of the machine has been enhanced in several minor points. The machine, as a whole, stands as formerly, as will be seen from the annexed illustration. Still it will be necessary for us to give in detail the alterations made upon the hitherto existing mechanism. These alterations consist principally in the manner in which the presser and friction bowl are controlled, the curved levers, with the weight sustained by them, being removed, and replaced by a simple and ingenious arrangement of levers, which are few in number, with a consequent absence of complication. The section block is, as in earlier machines, driven by a friction bowl sliding upon a horizontal shaft, and connected by a forked lever to a shaft which is rocked by the regulating screw by means of an L lever coupled to the latter. On the presser shaft, which extends across the machine, is a cranked slotted lever, also connected, as is shown in the illustration, to the regulating screw, which is operated as before, by a ratchet. An indexed regulator plate is fixed as shown, behind which is a star wheel indicating the number of hundreds of revolutions. As this part of the mechanism is substantially unaltered, it is not necessary to further describe it. A pin fixed in a brass nut, sliding in a graduated slotted lever which adjoins the cranked lever, engages with the slot in the cranked lever. The position of the nut is adjusted by means of a screw on which it fits and which extends downward in the slot. The upper end of the screw has a hand-wheel fastened on it, so that it is easy to set the nut as required. The graduated lever swings on a pin, is cranked at its upper end, and has a pin fixed at the end of its cranked end. A hand lever, which is pivoted at its lower end to a lever on the presser shaft, is formed with a slot at its upper end, one side of the slot being provided with a recess with which the pin in the graduated lever engages. The lever on the presser shaft is arranged to come in contact with an arm fixed on the shaft, and in this way the necessary depression of the presser arm is obtained. The action of this mechanism is as follows: The section block being empty, the presser is in its highest position, and the friction bowl is pushed into its initial position. In this case, the cranked lever is drawn forward by means of the screw, and it and the graduated lever are then practically parallel. As is well known, the practice is to form a trial cheese so as to be sure that the mechanism is in its proper position to produce sections of the requisite length and properly wound. One of the features of the new arrangement requires special explanation. As has been pointed out, the hand lever is slotted at its upper part, and in beginning to form a trial cheese, a hundred yards or so are first run on to the barrel, the graduated and hand levers being disconnected. If the nut is properly set, the pin fastened in the horizontal arm of the graduated lever can slip into the recess, or the hand lever can be easily pushed on to the pin, but, if not, the nut is moved in the slot until the pin will slip in, after which it is locked. By noticing the position of the nut, a record is obtained of the various points at which it should be set, or sec-

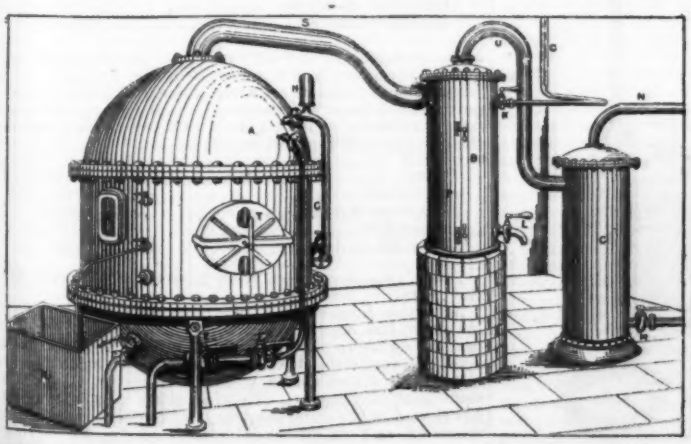


FIG. 1.

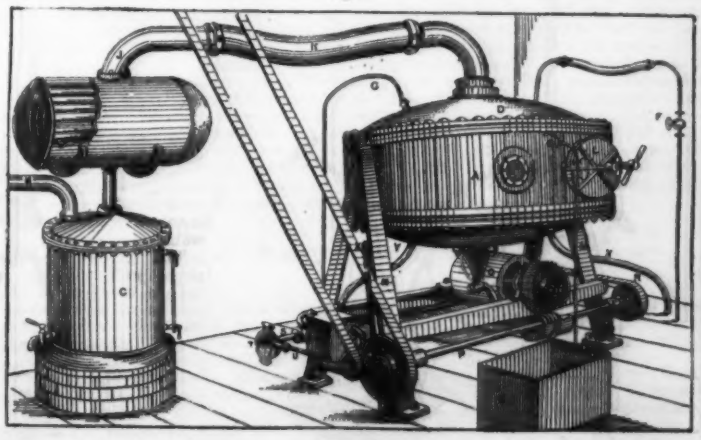


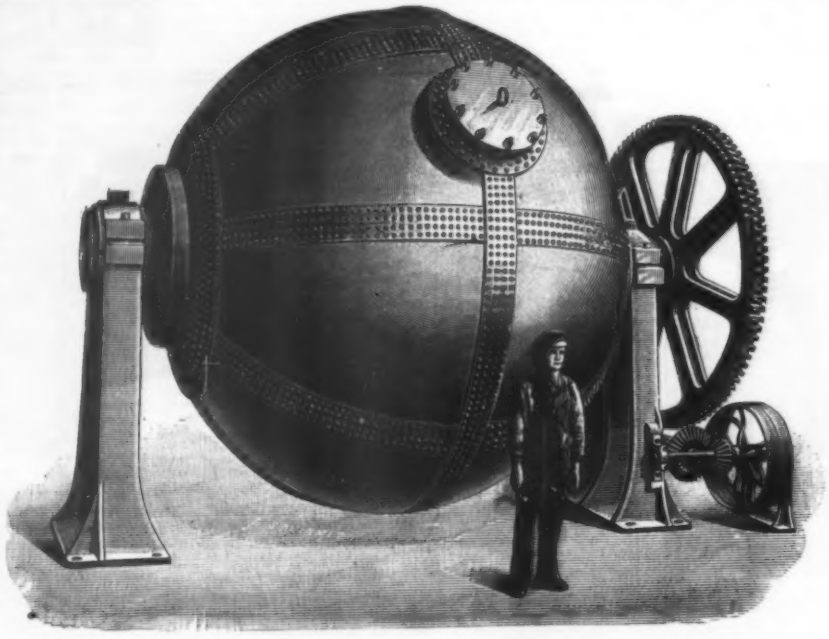
FIG. 2.

NEW APPARATUS FOR THE CONCENTRATION OF EXTRACTS IN VACUO.

tions of various counts. This is a valuable feature, and is sure to be appreciated. The operation of the rest of the mechanism is obvious. As the building of the cheese proceeds, the cranked lever is pushed inward, the graduated lever is also swung on its center, and the necessary withdrawal of the presser and friction bowl is thus readily obtained. By reason of the interdependence of the whole of the parts, the pressure put upon the cheese is constant, while the withdrawal of the friction bowl is effected at the exact speed required. The machine is very simple and easily understood, and no difficulty should be experienced by any warper in manipulating it. In construction, the machine is all that can be desired. It will be especially valuable to manufacturers of colored warp goods, and also to makers of balled warps.—*Journal of Fabrics.*

IMPROVED WOOD PULP DIGESTER.

THE engraving represents a very large wood pulp digester of the latest design. It is made of the best



IMPROVED WOOD PULP DIGESTER.

Siemens-Martin mild steel plates, $\frac{11}{16}$ in. thick, and 12 ft. in diameter inside. The rivet holes on the inside are countersunk to present a level surface to the lead lining, which is patented. The lining is made in large sheets, and is held against the steel shell by means of a series of clamps fastened from the outside. The digester is filled through the manhole, which is 2 ft. in diameter, from a high level, with timber and sulphite liquor, and steam passes in at a pressure of 70 lb. through the trunnions, while the digester is slowly revolved by means of the bevel and worm gearing, as shown in the engraving. The manufacturers are Robert Daglish & Co., St. Helen's, Lancashire, who at the present time, says *Engineering*, have upward of twenty such digesters in hand for this country and America.

THE WELLS LIGHT.

WE recently gave a notice of this invention, and now present additional engravings.

There are over 200 in use on the Manchester Ship Canal, and the contractor states that if it had not been for this portable light, night work could not have been carried on as effectually as it has been. It is especially adapted for lighting railway work, bridge buildings, coal wharves, docks, foundries, etc.

The tank is made of the best steel boiler plate, and will stand rough usage. By means of a small hand pump screwed into the top, and which can be quickly taken out for the renewal of leathers, etc., oil is pumped into the tank from a bucket or cask until the air already in the tank is compressed to about 25 pounds pressure. The burner is then heated by burning a little oily waste in the cup. The valve being opened, the oil is forced up by the air pressure into the heated burner, and being converted into gas, issues from the jet and burns as a large brilliant flame. The heat of this flame passing through the generating tubes continuously turns the fresh ascending oil into gas. The lamp is continuous in operation, as the oil can be pumped into the tank while the light is burning. When charged with air, at 25 pounds pressure, the lamp will burn for four or five hours, or until the pressure is reduced to 8 pounds, without regulating the oil tap feed. The falling pressure does not diminish the power of the flame. It requires no outside connections or continuous motive power, such as air or steam, and as the oil is driven out and burned as a gas, and not as a spray, there is no loss of oil when the flame is deflected by wind. When the light is used in a foundry or large works, one tank supplies all the burners with oil led through suitable pipes. The necessary pressure is obtained by connecting the tank with the town's water supply. The water can be regulated to any pressure by a reducer, and the only expense for driving is 1 gallon of water to 1 gallon of oil. When the water has pushed all the oil out of the tank, as shown by the glass gauge, the water is drawn off and the tank again filled with oil. The lamp burns a cheap creosote oil, obtained in the distillation of coal tar, and which costs in England 2d. or 3d. per gallon. Further information can be had by addressing Wallwork & Wells, 66 Duane Street, New York, care David Williams.

FIG. 1.—PORTABLE.

FIG. 2.—FOR HEATING OR LIGHTING.

THE WELLS LIGHT.

THE DEVELOPMENT OF GELATINO-BROMIDE LANTERN PLATES.*

THE time seems to have come when lantern slides can be made on gelatino-bromide dry plates which shall compare favorably with wet collodion or collodio-bromide transparencies, and shall be almost as certain in their preparation. For some time those who have occasionally tried their hands at transparency making on gelatine plates (and what amateur photographer has not?) must have felt that it was only a question of a developer, and, given that, success must be attained.

Ferrous oxalate has, as our lantern exhibitions have shown, produced transparencies which have left nothing to be desired either in the matter of color, of transparent shadows, or clear high lights; but when we have seen these selected specimens on the screen, the experienced among us have been apt to ask how many failures there have been before these casual successes have been scored. To obtain a good ferrous oxalate transparency, I think exposure must be absolutely correct and the developer must be in exact sympathy with the exposure; the result is then as good as need be. But this happy state of affairs rarely happens—certainly, if I may suppose my own experience to be that of others, not once in twelve times. The use of sulphite of soda or meta-bisulphite of potash with a pyro developer, joined, perhaps, to improved manufacture of plates, has made all the difference between certainty and uncertainty, and one may now calculate on getting ten or eleven good transparencies out of every dozen plates. Exposure within reasonable limits is not of such great importance, little more being necessary than to see that it is long enough.

Although I shall not be able to show on the screen any examples of transparencies from the same negative produced by three methods, I purpose showing a few developed by ferrous oxalate, and the same by pyro or hydroquinone. I shall also show some examples of wet collodion transparencies, and copies from the same negatives on gelatine developed with pyro or hydroquinone. Before showing these in contrast, I may say that I think collodion still carries off the palm; but gelatine follows so closely behind, that did we not see the two in actual contrast, I doubt if we could tell one from the other. Collodion *does* produce, in my opinion, shadows of greater delicacy and transparency.

I give now, in what I consider a reasonable manner, formulæ for the pyro developer recommended by two makers. Thomas gives in one ounce (approximately):

A.	
Pyro	2½ grains.
Sulphite of soda	7½ grains.
Citric acid	1¼ grains.

B.	
Bromide	2½ grains.
Ammonia	1¼ minims.
Carbonate of ammonia	2½ grains.

Take equal quantities.

In making up the developer, I confess I have not striven in some of the ingredients for mathematical exactness. Thus, in the item sulphite of soda, I have taken as much in my hand as I thought *would do;* I have dissolved this in *some* warm water, and have taken of this solution as much as I thought would about hit the prescription to a nicety. Again, not finding carbonate of ammonia in my stock of drugs, I used carbonate of potash, which I found to suit perfectly; indeed, the developer (and all developers I have ever seen) will stand a considerable amount of modification, according to the taste or fancy of the party, as Sam Weller says. The result of development, when carried out in the conscientious manner I have spoken of, is, when dry and viewed by reflected light, a whity-brown, approaching collodion color, with absolutely clear glass in the high lights.

Swan's formula is simpler, being—

A.	
Pyro	2 grains.
Meta-bisulphite	6 grains.

B.	
Bromide	2 grains.
Ammonia	7 minims.

The result by reflected light is a much redder brown than Thomas', but viewed as a transparency the color is much the same.

A very excellent developer is one half of which is taken from a formula given in the *British Journal Photographic Almanac* for 1888 by Mr. Edwards. It is a stock bottle made thus:

Ammonia	2 drachms.
Bromide	3 drachms.
Water	4 ounces.

Of this you may use as much as you like, but after many trials I have found about a quarter of an ounce to give about the best result. My formula would then be:

Pyro	2 grains.
Sulphite of soda	6 to 10 grains.
Edwards', as above	¼ ounce.
Water, to make	2 ounces.

The components of "Edwards" will be about, in this quantity, ammonia, 6 minims; bromide, 9 grains.

Mr. Brenan, some of whose slides I shall show presently, used Paget's developer, which is in great contrast with this last named one. In a two ounce solution the composition is about as follows:

Pyro	2 grains.
Citric acid	⅒ grain.
Sulphite of soda	8 grains.
Ammonia	1½ minims.
Bromide	⅛ grain.

These two developers show how wide the room for the operator's fancy is.

After development and before fixing, I put the plate for about five minutes in a solution of chrome alum, quarter ounce to the pint, and this has the important effect of rendering the film pretty nearly insoluble in hot water. Swan's film will not, however, stand the same heat as Thomas'. Two or three plates may be developed in the same solution (two ounces), and should there be any slight discoloration or deposit during development, a rub with the fingers in hot water entirely removes it. In fact, hot water is an excellent clearer and quite safe up to 110° to 120° Fahr. The disadvantage of chrome alum is that it is difficult to wash the films off the glass if you want to do so.

* A communication to the Manchester Photographic Society. Reported in *Br. Jour. of Photo.*

As well as the pyro developer, Thomas gives the following one for hydroquinone:

No. 1 STOCK BOTTLE.

Hydroquinone	160 grains.
Sulphite of soda	3 ounces.
Citric acid	60 grains.
Bromide of ammonium	20 grains.
Water to	20 ounces.

No. 2 STOCK BOTTLE.

Carbonate of potash	3 ounces.
Carbonate of soda (crystal)	3 ounces.
Water to	20 ounces.

Take equal parts.

This gives in two ounces of solution:

No. 1 STOCK BOTTLE.

Hydroquinone	8 grains.
Sulphite of soda	5 grains.
Citric acid	3 grains.
Bromide of ammonium	1 grain.

No. 2 STOCK BOTTLE.

Carbonate of potash	5 grains.
Carbonate of soda	5 grains.

This is really an extraordinary developer; it is quick, gives an admirable color, remains quite clear in use, and the same two ounces may be used for a dozen plates, one after another. I have developed fifteen, and the last one came almost as quickly as the first and was quite as satisfactory. It is necessary to develop to a slightly greater apparent density than is required for the result; the plate clears with perfectly bright high lights, and is satisfactory in every way.

I should say that all these developers produce equally satisfactory results with plates exposed in the camera or by contact to gaslight. I do not think there is a pin to choose between them.

Now, I am sure any one may make lantern slides, and good ones, too, and by gaslight may get through a dozen in an hour easily. In the camera the process is, of course, slower, every one requiring with a stop of $\frac{f}{12}$ an exposure of from four to fifteen minutes.

Exposure, whether to day or gas light, must be a matter of some uncertainty, and the best of us may have to intensify or reduce, and even those important processes may, I think, be safely carried out with gelatine plates. Before doing either, I consider it is much the best plan to first dry the transparency. I have not tried many reducers, but the safest and quickest I have found to be common chloride of lime in water. The action is almost immediate; but if the solution—or, I should say, the lime in suspension, for it does not dissolve—is not kept moving, a pitting of the gelatine takes place, which, if allowed to go on, quite ruins it. If the plate is put dry into the bleach, no alteration in color takes place, but a marked and immediate one is visible if the transparency is dipped into it before drying, the shadows assuming a bluish color; the transparent parts are also attacked and slightly clouded, which is not the case if the plate is put in dry.

Intensification is safe and easy, but it also should be deferred until after drying. The usual bichloride of mercury may be followed, after washing, by a solution of sulphite of soda, and the result is generally, but not always, successful. A few weeks ago a formula for intensification was recommended in the leading columns of *The British Journal of Photography* which seems to be an excellent one. It is as follows:

Bichloride of mercury	20 grains.
Chloride of ammonium	20 grains.
Water	1 ounce.

Wash well and tone with—

Liver of sulphur (sulphide of potassium)	20 to 60 grains to 1 ounce.

The latter substance has a dreadful smell, exactly like the choicest Harrogate sulphur water, but it produces capital tones, and great variety of color may be obtained from it. I think it a very useful addition to our laboratory, notwithstanding its unsavory qualities. I may add that I think a better color is obtained if, after washing the chloride-bleached picture, it is dried again before putting it into the liver of sulphur solution.

ABEL HEYWOOD, JR.

A MINIATURE STEEL WORKS.

IN forwarding to the Government Central Museum samples of steel manufactured at a village in the Trichinopoly district, together with the ordinary earthenware crucibles used in the operation, the board of revenue has also furnished the following communication from the collector of the district on the method of the manufacture: "The industry is carried on at a small village called Venkatanaikanpatti, about two miles from Parvarankurichi, occupying a favorable situation for obtaining charcoal from the surrounding hills of the Marungapuri Zemindari. It affords employment for about sixteen families of smiths, and is altogether in the hands of a Mussulman named Mahomet Routhen, who holds a monopoly of the right to collect charcoal for the purpose in the jungles of the estate, for which he pays 1,000 rupees per annum. Beyond the convenience of its situation as regards jungles and the existence of tolerably fine red earth in the vicinity, the site possesses no special advantages. The process employed is very simple. Small quantities of iron are inclosed in a small earthen crucible with a few pieces of the wood of the avaram plant and two or three green leaves. A top is luted on, and when dry the whole is exposed to the heat of a small charcoal furnace till the iron is melted, a fact which the operator ascertains by picking up the crucibles in a long pincer and shaking them. The vessels are allowed to cool and then broken open, when a knob of steel is found at the bottom.

Two sizes of ingots are made, weighing about 8 ounces and 10½ ounces respectively. The crucibles are made of a mixture of red earth and charcoal made of paddy husks kneaded together. They are shaped on a wooden plug about five inches long and two inches in diameter for the smaller size of ingot, and slightly larger for the other size, having a conical end which forms the bottom of the cavity in which the steel collects while fluid. The lid is of the same material and put on wet. It appears hardly to contract at all in drying, and a fairly air-tight vessel is consequently produced. The clay is not nearly refractory enough for the heat it is exposed to, as the crucibles are completely vitrified and spoiled at the end of a single operation.

The iron used is brought from the Namakal Taluk, of Salem, and appears to be a rough description of wrought iron. For the smaller size of ingot it is cut into pieces weighing as nearly as possible 10 ounces (a small piece is added to make up the weight, if necessary), and this quantity is placed in each crucible with ¾ ounce weight of pieces of the dry wood of the avaram plant. Two or three green leaves (the kind is a matter of no consequence) are placed on top, and the charge closed up with a lump of clay carefully plastered all round. Great care is taken in putting in the correct proportions of iron and avaram wood, and the operators assert that, if less is used, the iron is not melted, and if more, it will not stand being worked afterward. The green leaves probably serve in some way toward retarding the drying of the lid and preventing it from cracking. The furnace consists of an inverted cone of earthwork about two feet in diameter, and the same in depth, the apex opening into an ash pit below. At one side, and protected from the heat by a mud wall, is a small shed in which two bellows men sit and work a pair of skin bellows most vigorously. The air is admitted into the furnace through a hole near the bottom. In preparing a furnace some straw is first placed at the bottom below the air hole, and charcoal is then thrown in to a suitable height. On this 25 of these conical crucibles are placed with the point downward, and when all are in position they appear to form a sort of circle and to be independent of the layer of charcoal below. More charcoal is placed above, and the furnace is then lighted through the air hole. Fresh fuel is thrown on above from time to time, and one or two of the crucibles are occasionally lifted with long-handed pincers to allow the burning charcoal to fall through and replenish the supply below. The straw remains untouched by the fire throughout the process. The crucibles are given a sharp shake on these occasions, which is said to assist the process, and, toward its conclusion, allows of the operator's ascertaining whether the iron is melted or not.

As the mouth of the furnace is open, the waste of fuel is enormous, and I do not believe that one-fourth of the charcoal used exercises any effect on crucibles. In the absence of good fine clay this fault seems irremediable, as there is no sufficiently refractory metal available from which a separate opening for the supply of charcoal to the furnace below could be constructed. After about an hour or an hour and a half the feel of a crucible when lifted shows its contents to be liquid. The process is then considered to be completed, and the crucibles allowed to cool, after which they are broken open, and a knob of steel found at the bottom of each. The ingots are reheated and hammered into oblong pieces, in which shape they are sold. All the crucibles do not remain absolutely air-tight during the process, the lids becoming cracked without affecting the result. I had the contents of one of these poured out through a crack, and was surprised to find the steel in a state of extreme fluidity, a thing which the heat produced hardly led me to expect. The estimated cost of making 200 pounds of steel is about 31 rupees, and the value realized for the production about 36 rupees, the manufacturer netting a profit of 5 rupees or about 16 per cent. The annual outturn of the manufactures in the village is about 28,000 pounds.—*Indian Engineer.*

ZENOBE GRAMME.

EVERY one has heard of the Gramme machine, which, as well known, has rendered electric lighting practical, just as the Seguin tubular boiler rendered railroads possible; but, as celebrated as the invention is, there is little known of the inventor. A recent decree naming Mr. Gramme an officer of the Legion of Honor, while at the same time awarding him the Volta prize of $10,000, must have taught more than one ignorant person that the dynamo-electric machine does not owe its name to the unit of weight of the metrical system. The reason that he is not known is because, in the midst of a prosperity of which the history of inventions offers, alas! but few examples, he has retained all the simplicity of his humble origin. It was with great difficulty that we were able to procure his portrait, which has never before been published.

Zenobe Gramme, born in 1826 at Jehay Bodignee (province of Liege), had reached the age of 34 years when, in the capacity of a pattern maker in joinery, he entered the shops of the Alliance Society, which was constructing the Nollet magneto-electric machines designed for the lighting of lighthouses. The mysterious phenomena of induction, of which these apparatus were an application, impressed him deeply. He tried to have them explained to him, but he had no education, and was obliged, like Pascal in reinventing geometry, to compose a theory for his own use. During his meditations, he had occasion to open a work on physics owned by one of his friends, and was thoroughly surprised on reading it to find himself coinciding with Franklin and Ampere in some of his hypotheses.

ZENOBE GRAMME.

It was a revelation to him. He bought Ganot's Physics, but the terms in this work, although very elementary, perplexed him at every instant, and it was necessary for him to seek the aid of a dictionary in order to understand them. Just imagine the efforts of this quick but untutored mind laboring thus without professor or guide! A few years later on, this hard labor bore its fruit. After improving the magneto-electric machine based upon the induction of currents by magnets, Gramme perceived the numerous drawbacks of this system and conceived the idea of producing the current by the reaction of two electro-magnets upon each other. In 1869 he devised the Gramme ring, which solved the problem and served him as the starting point for all the dynamo-electric machines. Industrial electricity was created. We see it as yet but in its beginning; we can predict incalculable developments for it. Electric lighting, the transmission of power, and electro-metallurgy (which is on the high road to enriching us with new metals), are as yet only the first results of it, and the name of Gramme, its initiator, will beam in the history of inventions with a radiance equal to that of Watts, Stephenson, and Ampere.—*Science Illustré.*

ELECTRIC WIRING OF BUILDINGS.*

By J. D. F. ANDREWS.

THE first points for consideration in devising a wire system for electric lighting are, What contingencies will be met with that will affect the system, and what faults will arise in it after its introduction?

Throughout past experience it has been found that the practical pressure of electricity for electric lighting is, within fifty per cent. either way, about 100 volts—the 100 volts being most generally adopted. The chosen conductor is copper, and the most widely adopted insulation is India rubber, in many modified forms;

* Paper read at the Philosophical Society of Glasgow.

the insulated conductors are usually protected and held in position by wooden casing.

We need hardly question the object of the conductor, but what is the object of the insulation? The conductors if held in good dry wood casing only would be protected from interference. Its object is to meet one of the worst contingencies—moisture or water—which is an ever-working evil on electric light wires. If you place a copper wire in water with electricity passing along it, the copper will be removed electrolitically from the part of the wire where the electricity enters, and deposited where it leaves.

The same process goes on where uninsulated or badly insulated electric light wires lie in water or surrounded by moisture. Even though no electricity is flowing through a copper wire exposed to moisture and the atmosphere, it is acted upon chemically. The result of the electrolitic and chemical actions on electric light wires is to thin them and make them insufficient for carrying the current, and consequently they become heated. Or the result may be that the wire is eaten through when an electric arc is produced.

This effect or fault is called an opening circuit, and is about the most difficult and dangerous fault to contend with. It is usual to lay the electric light leading wire in a groove in the casing neighboring and parallel to the return wire. Water often saturates the casing between them, and when the insulation is poor, the electricity will pass through the moistened wood and char it, often setting it in flames.

Faults such as this where a great leak is taking place between the wires are called partial short circuits, and are equally difficult to avoid and as dangerous as opening circuits. The study of the insulation of the wires is therefore obviously of great importance. Most of the results in good insulation were obtained by telegraph engineers before the electric light business was started, but in the new businesses these results were almost entirely ignored. Great insulation was then not considered necessary. Special covering for the wires was devised of a cheap and poor quality, which, it is greatly to be regretted, has continued in use by many contractors to the present day.

As previously stated, India rubber is the base of the insulation of most electric wires, the purer the material the better the insulating properties; but pure India rubber is easily influenced by air: at first it gets hard, and in course of time changes to a soft, sticky state, when it is useless as an insulation. Pure India rubber is still the foundation of insulation on the wires, but in the very best qualities it is protected from the atmosphere by an outer coating of what is known as vulcanized India rubber.

Such qualities of insulation consist of first one or two lappings of pure India rubber, then a layer of India rubber mixed with such minerals as soapstone, over which again is laid a coating of rubber mixed with a large proportion of sulphur. The wire, with its three coatings, is now subjected to a high temperature in a vulcan by means of steam, through which the rubber and sulphur combine, while any surplus is absorbed by the middle coat, which is called the separator.

Such is the insulation of the best quality wires; the inferior qualities and those most generally used are insulated simply with pure rubber and cotton serving with ozokerite or other compound tape laid together in many different ways, according to the device of the makers. The compound tape is supposed to protect the pure rubber from the air, but it only plays this function to a small extent. The usual reliable life of such wires is from two to three years, and not being reliably waterproof throughout their length, at any time there is always danger of failure through moisture.

Vulcanized India rubber covered wires of the class above described—there are many inferior kinds—is perfectly reliable in water or air for a great number of years. The next contingency that has to be contended with is mechanical damage. The wires being more or less flexible and the covering soft, they are easily damaged. This difficulty is usually met by casing the wires in wood, and it being necessary to employ two conductors for electric lighting, the casing has two grooves, one for each conductor—a cover being fixed over them. Wood casing has the disadvantage of harboring moisture.

Another method of protecting the wires is that of sheathing them with an outer covering of wire as introduced by the writer some years ago in ship lighting. This method protects the wires much more effectually than casing and does not harbor moisture. Iron pipes have been used in many cases, and are excellent protection; but moisture collects in them, and if there should be a fault in the insulation, it is sure to find it.

There is another fault besides the opening circuit and partial short circuit not yet touched upon—namely, a dead short circuit, or a direct contact between the opposite conductors. This is the most frequent fault, and if it were not that there is a simple appliance, called a fuse, to meet it, it would also be the most dangerous fault. Short circuits usually happen in the fittings where the opposite conductors are necessarily brought nearer each other, and at these points the insulation is generally much thinner and poorer. Short circuits also often happen where the wires cross, and frequently by contact with gas or water pipes, which make very complicated faults, because the two wires usually touch the pipes a distance apart, which will be better understood by reference to Diagram 1.

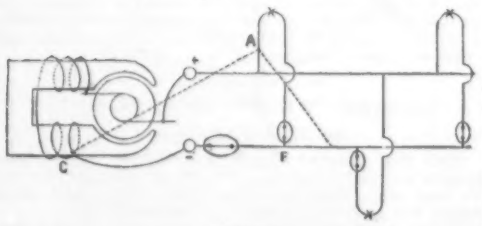


Diagram 1.

Suppose the current to leave the dynamo by the positive wire, pass to the lamps by the branch wire and back by the negative branch wires through the fuse, F, and the negative main to the machine. Suppose now the positive branch becomes connected to a gas pipe at say A. This would not indicate itself in any way, and the installation would of course continue working just the same until the opposite wire got connected to the gas pipe, say at B. Now the current will become excessive, more than the branch wire can carry without getting dangerously hot, before the main fuse, T, melts.

In the above description it is assumed there is a safety fuse at F, but it will be observed the short circuit has bridged the wire in which it is inserted, and it is consequently useless to avoid the excessive heating of the wires with such faults above referred to. It is necessary to have fuses, one on each wire, such as at F and S. Under such circumstances, when a short circuit, such as described between A and B, takes place, the fuse, S, would immediately blow and prevent danger. Let us again assume there are fuses on only the negative wires, we will see there might have been even a worse fault.

Again, supposing a connection at A with the gas pipe, which is, of course, connected to the earth, we will assume the second connection to take place in the dynamo field magnets at C. The current will now traverse the positive wire to A, thence to the gas pipe to earth, and back to the dynamo. This route is a short circuit, and one, moreover, that bridges both branch and main fuses, which we have assumed to be only on the negative wire, as is still the practice of some contractors. The consequence of this short circuit is similar to the one from A to B, but worse, because there are no fuses at all left to protect the system.

Of course, with another main fuse on the positive wire, such a short circuit could not continue. There is, however, objection to the multiplication of fuses. They are a danger themselves sometimes, such as in the case of a partial short circuit that does not increase the current sufficiently to melt the fuse, but quite sufficient to heat it to a degree dangerous to any inflammable material in the neighborhood; and it may continue in this condition some little time before it fuses, especially if it is a large one.

Another point of danger from a fuse is when it melts it throws out sparks of molten metal. Of course, it will be said that the evils in fuses can be reduced by proper construction. That is true; but it is decidedly better to avoid, if possible, numerous points of danger in an installation resting on special construction or the care of an attendant for their prevention. We will consider later how this to a certain extent can be achieved.

In the foregoing we have considered mainly the contingencies or dangers arising with the introduction of electric light into buildings, and we may summarize the main points as being an opening circuit, a partial short circuit, a dead short circuit, and the fuses. We have considered the dead short circuit to be met by the fuse, although a new element of danger is introduced, which, however, is much less in degree.

This new element of danger can be reduced to one-half by connecting one of the leading wires, say the positive, to the earth and the gas and water mains, it being only on account of the latter that it is otherwise necessary to provide a fuse on each wire. Diagram 2 will show this more plainly: The current leaves the

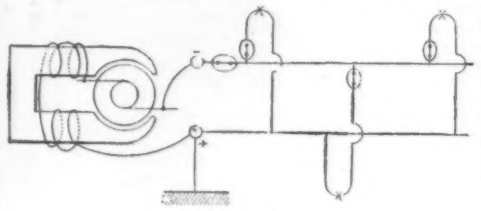


Diagram 2.

dynamo by the positive terminal, and meets at once a connection to earth, and the gas and water mains, then proceeds by the positive wire to the lights and back to the dynamo.

This connection to earth is willfully effecting the fault we supposed might happen, as in Diagram 1. But in making the connections to earth we are careful to do so with that wire which has not got the fuses inserted in it, which is contrary to the action of the fault in Diagram 1. Now, if any of the negative wires come in contact with the gas and water pipes, a fuse must instantly blow as if their two conductors themselves had touched.

All the electric light fittings would in this case be connected with the positive wire, the negative wire passing down the center of the tubes. There being in the fittings only a single wire, which can be heavily insulated and made stouter, there is an additional safety against short circuits and fuse melting, besides

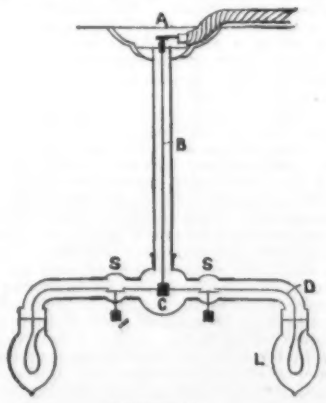


Diagram 3.

the very great advantage of being able in a very simple way to wire each part of an electrolier or fitting. Diagram 3 illustrates how this is effected. The current travels from the contact, A, down the wire, B, through the contact, C, to the switches, S, S, by the wire, D, to the lamps, L, and back by the brass of the fitting to the ball and socket at the top, and away by the earth wire.

The wire inside the tubes is never smaller than No. 14 S. W. G., and the contacts are made with a strong small spiral spring. The contact at the ball and socket joint projects through, and, being a box spring, it gives and takes with the swing of the fitting, and scrapes on a fixed brass plate in the roof plate. Single or universal joints are quite simple to construct with this system within the same dimensions as for gas; whereas with the two wires passing through the fitting, such is impossible.

This method of connecting one of the wires to earth is best called the earth system. It is, however, often called the single wire system, because in its applications to ships the hull of the ship is used as the return wire. In buildings, however, two conductors are required, and, as it is important always to be able to distinguish between the negative wire, in which the fuses are inserted, and the positive wire, which is connected to earth and all the electrical fittings, the positive wire is colored red, and the negative wire black. The object for connecting the positive wire to earth is that red colored wires are usually inferior in insulation quality to black wires, and it is not so important that the return or earth wire should be so highly insulated as the leading wire.

We now come to the consideration of means for minimizing those most dangerous faults, opening and partial short circuits. Except the means proposed by the writer in the following paragraph, no attempt has been made to treat these faults, except by good workmanship and material. The proposal the writer makes is to universally adopt the sheathed or armored wire system devised by him some years ago for use in the exposed and damp places on board ships using the earth wire system, and now extensively used for that purpose.

The virtue of this system is that all faults, partial short circuits, and opening circuits are reduced to dead short circuits. Diagram 4 is an enlarged section of an

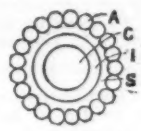


Diagram 4.

armored wire such as is now in use. The pink portion, C, is the copper conductor; I is vulcanized India rubber insulation of the highest class, with a serving of jute and special compound between it and the iron armoring, A, which is a great many times larger in cross section than the copper conductor, care being taken that it is always more than seven times larger, this being about the difference in electric conductivity of the two metals.

It will be understood that the copper wire is the lead and the iron wire the return. It was assumed in devising this system that an opening circuit in the outer conductor was very unlikely to take place, and so it has been found in practice. It is, however, possible that the inner conductor, through undue strain or a flaw, might have an opening circuit in it, and if such were to take place, the immediate result would be that the heat generated would destroy the insulation between the two conductors, and at once effect their fusion together and a short circuit. As a matter of fact, however, short circuits in this system have in practice been many fewer, and there have been no opening circuits or partial short circuits. How many of the short circuits were due to such faults is difficult to say—the causes of some were doubtful.

The writer is not aware of any new danger or contingency being introduced with this system of concentric wiring, although he has heard that some people object to it, and, in fact, any system in which an earth connection is introduced; but he has still to learn upon what grounds the objection is based.

In addition to the advantages above referred to, there is another of not the least importance. The electricity being entirely inclosed within the outer conductor, and the electric pressure being only from the center point to the outer conductor, it is impossible to get a shock through anything more than a very small portion of one's flesh, such as the finger end, except by willful contrivance.

It is advisable, before closing this subject, to consider how a system of wires supplying a town would be affected by an earth connection of one of the conductors. With any system of supply embodying the series system, I may generally say it is not advisable to employ an earth. I have expressed this point broadly, as it involves complex considerations which would take long to make quite clear. But with all systems on the parallel system, there are many points favorable to an earth connection, some of which can be gathered from foregoing descriptions. It is more important for us to find out whether there is any objection to its use, and with this in view Diagram 5 is placed before you. It

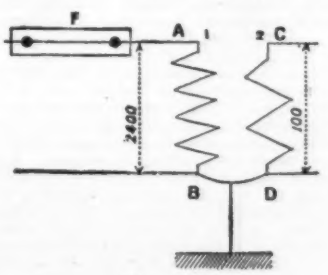


Diagram 5.

illustrates a transformer with its primary leads, and an electric pressure of 2,400 volts at the terminals, A and B, where they join the primary circuit 1 of the transformer. F is a fuse in the primary circuit. 2 is the secondary circuit of the transformer between the termi-

nals, C and D, of which there is represented a pressure of 100 volts. The terminals, B and D, of the circuits of the transformer are connected to earth, and consequently connected together. The writer is unable to find any danger in thus connecting the 100 volt pressure circuit to the 2,400 volt pressure circuit. Nobody could get a shock to earth, because the pressure between the return wire and earth is reduced to nil. The next point is, is there any greater probability of the insulation of the transformer breaking down because the circuits are joined together at one end? This seems to the writer to be answered by a simple calculation. With the earth connection there is no pressure at one end, but all the pressure, whatever it is, at the other. With no earth connection the pressure is alike at both ends, but at each it is only half the total. The result in both cases is the same. Suppose a connection did get made between the terminals, A and C, in addition to the earth connection, why the 2,400 volt circuit would be simply short-circuited, and the fuse, F, would melt. There is, it is true, a very remote possibility of danger in the event of the great improbability of three circumstances happening in succession—viz., first of all, a connection between the terminals, A and C, as well as the earth; then the fuse, F, not melting; and thirdly, the circuit of the secondary of the transformer to open between the terminals, and thus put the 2,400 volts pressure on to the lamps direct, which would, as a matter of course, immediately gasp their last.

There is one other circumstance worthy of mention in favor of the earth connection. Should the wire system at any time be struck with lightning, there is at once a safe connection to earth. Instead of having to pass through a highly insulating material, as when there is no earth connections, lightning has already been known to strike overhead electric light wires, and discharge itself through the dynamos to earth, to the imminent danger of the machine.—*Electrical Engineer.*

A NEW PHOTOMETER.

THE apparatus described below by Dr. O. Lummer and Dr. E. Brodlum is designed to replace the ordinary photometer disk by a true optical combination.

Fig. 1 shows a cross section of two glass prisms, A

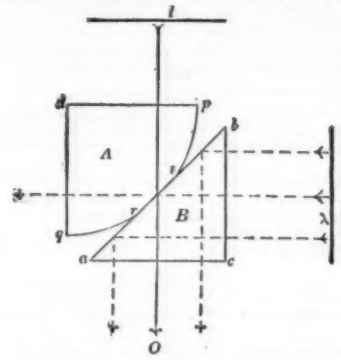


Fig. 1.

and B. B is an ordinary totally reflecting prism, with a perfectly even face as its hypotenuse, while in the prism, A, only the circular face, *r s*, is perfectly even, the other portions, *q r* and *s p*, forming the zone of a sphere. Both prisms are so intimately pressed together at *r s* that all light falling on this plane of contact passes through it without loss. An eye placed at O receives light from *l* only through the contact surface, *r s*; on the other hand, from λ only such rays as are totally reflected from *a r* and *s b*. If *l* and λ represent surfaces illuminated by diffused light, and if the eye is fixed on the plane, *a r s b*, it generally perceives a sharply defined bright or dark elliptical spot in an equally illuminated field. If both sources of light are equal, this spot disappears completely. Other similar apparatus have been partially investigated, which have yet in part to be tested. So far the arrangement just described has given the best results.

In Fig. 2 the disposition of the photometer is sketched

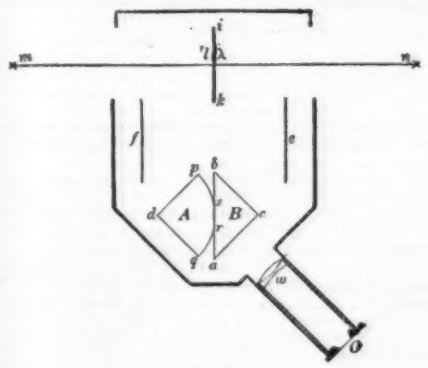


Fig. 2.

as utilizing the foregoing principle. It was thus set up in the Royal Institute for our investigations. The screen, *i k*, stands vertical to the axis of the photometer bar, *m n*. It consists of two sheets of paper, between which tin foil is secured. The diffused light from the screen, *i k*, falls on the mirrors, *e* and *f*, which reflect it vertically upon the faces, *c b* and *d p*, of the prismatic combination, as shown in Fig. 2. The observer sees the face, *a r s b*, clearly through the adjustable lens, *w*.

Among the advantages of this photometer is the additional one, which must not be underestimated, that it is free from the liability to change of Bunsen's disk (paper with a grease or paraffin spot) and from the unequal reflecting powers of the two sides of the spot. It may be briefly noted that by proper disposition of parts the same advantage is obtained as by observations of both sides of the Bunsen disk. Measurements obtained with a temporary apparatus confirm perfectly the superiority of the principle of the new photometer compared with the Bunsen disk, as should have been anticipated. The arrangement adopted makes it possible to place the apparatus in the place of Bunsen's disk upon the bar of any photometer.—*Zeitschrift fur Instrumentenkunde.*

THE ELECTRIC LIGHT AT THE PARIS EXHIBITION.

M. HIPPOLYTE FONTAINE read a paper on this subject at a recent meeting of the International Society of Electricians in Paris, from which we extract the following particulars. The total cost of the exhibition to the French government and town of Paris is estimated at about £2,000,000. There are, in round numbers, 50,000 exhibitors, of whom each will spend on an average £120, representing an additional outlay of £6,000,000, so that the whole cost of the exhibition may be roughly estimated at £8,000,000.

The total earning capacity of exhibitions depends, among other things, upon the number of hours during which the public has access. If no artificial lighting were used, the total number of hours would amount to 1,620; but by the adoption of the electric light, this number has been increased to 2,520, reducing the cost of the exhibition per hour from nearly £5,000 to a little over £3,000. Although this is a substantial gain wholly due to electric lighting, the administration have not cared to erect the necessary plant at their own cost, or to pay for the light at a fixed rate, as they do with steam, water, gas, etc.; but they have agreed to hand over to the purveyor of the light one-half the entrance money received from visitors in the evening, and which is fixed at 2 fr. on week days and 1 fr. on Sundays. The electric lighting plant has been provided and will be worked by the Electric Lighting Syndicate, which has been formed with a view to make the lighting an international undertaking.

The lighting has been divided between a number of firms and systems, and this will afford an excellent opportunity for comparisons. The machinery hall, which has a floor space of 77,000 square meters (or about 19 English acres) and a volume of 2,000,000 cubic meters, will be lighted by arc lamps of various sizes. The largest lamps are those arranged in four groups of twelve lamps close under the ridge of the roof. These will be 60 ampère lamps, and will burn 25 mm. carbons. They are indicated on the plan and transverse section given herewith by the black dots clustered together. The other black dots, which are further apart, represent the distributed lamps. Of these eighty-six are 25-ampère lamps distributed in five longitudinal rows, and suspended about 15 m. from the floor. The side galleries of the machinery hall and the stands adjacent to them will be lighted by 276 8-ampère arc lamps suspended 5 m. from the floor. The lighting is being undertaken by the following contractors:

FOR THE 25 AMPÈRE LAMPS.

Crompton & Co.	24
Maison Ducommun	20
Sautter, Lemmonier & Co.	12
Jaspar	11
Société Belge	6
Borssat	5
Société Francaise de Materiel Agricole	4
Henrion	4

FOR THE 8 AMPÈRE ARC LAMPS.

Crompton & Co.	79
Maison Ducommun	76
Sautter, Lemmonier & Co.	30
Alioth & Co.	30
Oerlikon Works	25
Société Francaise de Materiel Agricole	8
Société Belge	8
Henrion	8
Jaspar	7
Popp & Co.	5

In addition to the arc lamps, there will be various installations of glow lamps, contracted for by the following firms:

Woodhouse & Rawson	8	of 200 c. p.
Garnot	10	" 250 "
Jarriant	360	" 8 "
Crompton	160	" 8 "

The annex devoted to railway exhibits, which comprises nearly 6,000 square meters of surface, is to be lighted by five 25-ampère and thirty 8-ampère arc lamps by M. Borssat, while the large central dome will be lighted by the Societe Gramme by forty-eight glow lamps of 500 c. p. Besides the spaces here mentioned, the various other annexes and courts will receive separate installations, but want of space precludes our giving a full list. In the open spaces the lighting will principally be effected by continuous current arc lamps and Jablochkoff candles, and the work is divided between the Paris Edison Co., the Rothschild-Marcel-Deprez combination, the Maison Ducommun, and the Societe l'Eclairage Electrique, who work the Jablochkoff system.

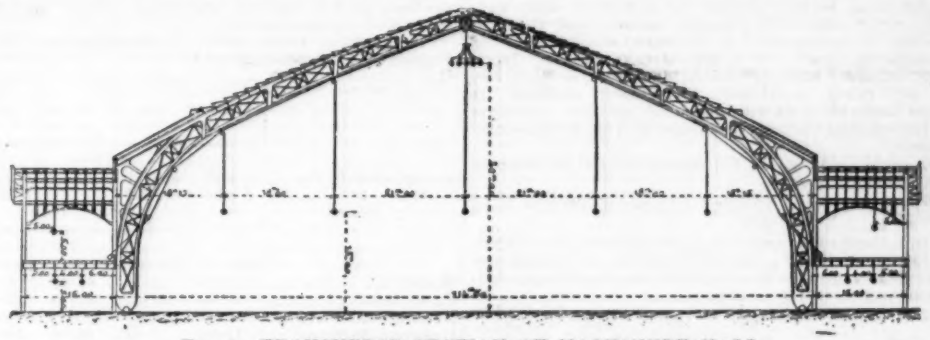


FIG. 1.—TRANSVERSE SECTION OF MACHINERY HALL.

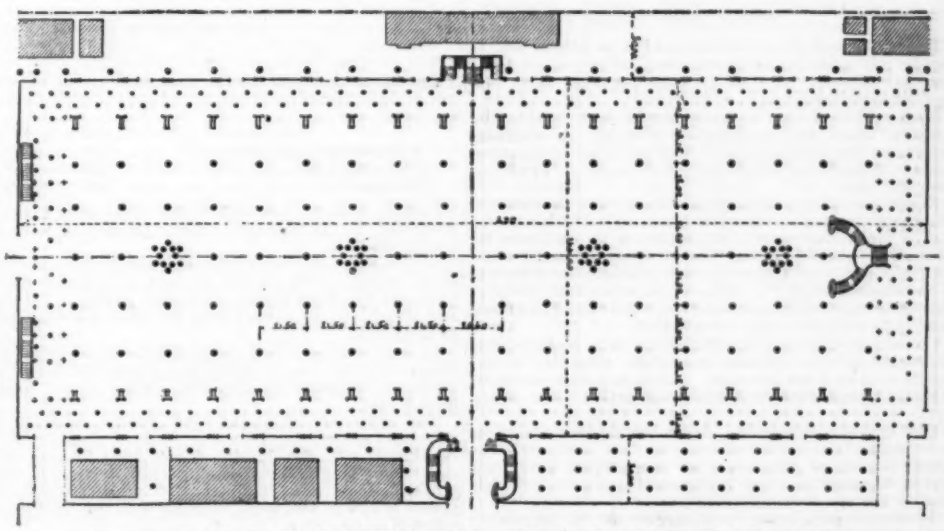


FIG. 2.—PLAN OF MACHINERY HALL, SHOWING POSITION OF LAMPS.

ELECTRIC LIGHT AT THE PARIS EXHIBITION.

The large fountain which is being erected by Messrs. Galloway, of Manchester, in conjunction with the administration, will be lighted by the Gramme Co., of Paris, with forty-eight arc lamps, requiring about 250 horse power. There will, however, be a second fountain erected by Messrs. Galloway, who are for this purpose utilizing the plant which was in use at the Manchester exhibition, and this fountain will be lighted by eighteen 60-ampère arc lamps. M. Fontaine gives the following table, showing the total amount of light which will be nightly employed:

Lamps employed.					Units of 1,000 candles.
51 ares of 60 ampères					510·0
100	"	25	"		350·0
10	"	15	"		20·0
726	"	8	"		726·0
97 Jablochkoff candles					38·8
16 sun lamps					16·0
72 glow lamps of 500 candles					36·0
10	"	"	250	"	2·5
3,500	"	"	10	"	35·0
6,500	"	"	5	"	32·5
Total					1,766·8

In this table we have, for simplicity, assumed that one carcel is represented by ten standard candles. Correctly speaking, it is 9·6 candles, and the total amount of light will thus be reduced to about 1,700,000 candles. There will thus be employed in the lighting of the exhibition a candle power close upon 1¾ millions.—*Industries.*

GYMNEMIC ACID.

By DAVID HOOPER, F.C.S., F.I.C.

SOME years ago it was discovered by Mr. Edgeworth that the leaves of *Gymnema sylvestre* had the peculiar property of destroying the power of the tongue to appreciate the taste of sweet substances. In the early part of 1887 Sir M. E. Grant Duff, then Governor of Madras, interested himself in the subject, and forwarded me from his grounds in Grundy Park a supply of the leaves for investigation. A paper containing the results of a chemical examination, with their proximate analysis, has already been published,* and now some notes are sent relating to the chemistry of the principle possessing this singular property, which was discovered at that time.

Gymnemic acid exists in the leaves in the form of a potassium salt, and is best prepared by treating the aqueous solution of the alcoholic extract with a mineral acid, washing the precipitate, and drying in a current of hot air or over a desiccator.

The acid is a brittle black resinous substance, of a greenish color when reduced to powder. It is insoluble in water, soluble in alcohol (with an acid reaction), ether, benzol, and chloroform, and slightly in amylic alcohol and carbon bisulphide. With potash, soda, and ammonia it affords fine red solutions with an orange-colored froth, and precipitated on the addition of acids. It dissolves in concentrated sulphuric and nitric acids with intense red color, and in both mixtures it is destroyed and precipitated by water. Prolonged contact with nitric acid forms a soluble nitro compound or product soluble in water.

It fuses at about 60° C. into a black liquid of thick consistence; above 100° it gives off creosotic fumes, and, at a higher temperature, burns with a bright smoky flame, leaving no ash. It is thrown down as a bulky gray mass with plumbic acetate, and the lead salt may be decomposed by hydrogen sulphide in the presence of spirit. It is also precipitated by ferric chloride, silver nitrate, barium and calcium salts, but not by tannin, picric acid, and gelatin solution. It forms insoluble salts with alkaloids, and this accounts for its masking the taste of quinine and other bitter substances.

The acid, dried at 100° C., was submitted to combustion with cupric oxide.

(*a*) 0·2152 grm. gave 0·4807 grm. CO_2 and 0·1706 grm. H_2O.
(*b*) 0·2738 " 0·6080 " " "

From these experiments may be deduced the empirical formula $C_{28}H_{44}O_{13}$; the recalculation of the elements from such a formula shows a close correspondence with the mean percentage found.

	(*a*)	(*b*)	Mean.	Calculated for $(C_{28}H_{44}O_{13})$.
Carbon	60·92	60·55	60·73	60·85
Hydrogen	8·80	8·61	8·71	8·71
Oxygen	30·28	30·84	30·56	30·44
	100·00	100·00	100·00	100·00

The silver salt of gymnemic acid is a black brittle powder; it afforded 14·02 per cent. of metal on combustion. Theory for $C_{28}H_{44}O_{13}Ag$ requires 14·63 per cent. of metallic silver.

Gymnemate of lead is insoluble in acetic acid, and forms a black uncrystallizable powder. A weighed portion of the dried salt gave 15·19 per cent. of plumbic oxide. Theory for $(C_{28}H_{44}O_{13})_2Pb$ requires 15·20 per cent. of PbO.

There is evidence that gymnemic acid is a monatomic acid from the compositions of its silver and lead salts, and its molecular weight, 631, agrees with its power of saturating alkali. It was found by experiment that 0·631 grm. of the acid, treated with centinormal solution of caustic soda, did not strike a red color with phenolphthalein until sufficient solution, equivalent to about 0·040 grm. of NaHO, had been added.

I have not obtained the acid or its salts in anything approaching a crystalline condition; they dry as do tannic acid and the tannates. Ammonium gymnemate exhibits the characters of the drug better than other salts.

The acid is a glucoside. After boiling for about an hour with dilute hydrochloric acid, a dark resinous mass, devoid of the peculiar property of gymnema leaves, remains, and the liquor contains a body which readily reduces Fehling's solution.

Gymnemic acid occurs in other species of *Gymnema* besides *sylvestre*. *G. hirsuta* contains a considerable quantity, and *G. montanum* leaves contain it in a smaller proportion.—*Chem. News.*

* *Nature* and *Pharm. Journ. and Trans.*, April, 1887.

YORKSHIRE GREASE.†

By GEORGE H. HURST, F.C.S.

IN our technical literature but few references are to be found on this subject, and even these of a limited scope.

I propose to deal with the subject under two heads:

1. Yorkshire grease: Its origin, composition, and the products obtained from it.
2. The composition and properties of these products.

Yorkshire Grease: Its Origin, etc.

In the woolen industry a large quantity of soap and oil is used in cleansing, milling, and oiling the fiber, yarn, and cloth during the different processes involved in spinning and weaving wool. Formerly, all these products, or rather the waste from them, went into the rivers in the form of soapsuds, and thus helped to pollute them.

Now, almost the whole of the soapsuds of the woolen mills of Yorkshire and other districts are treated with acid and the fat liberated used again for making soap.

The soapsuds are collected into a large tank, calculated to hold a day's supply, say from 6,000 to 8,000 gallons of liquor. Usually two tanks, constructed of brickwork or concrete, are provided, one being used to collect the suds, while the suds collected in the other tank are being treated in the manner following:

Brown oil of vitriol, or, preferably, hydrochloric acid, is added to the suds, and after thoroughly agitating the mixture it is allowed to settle; the fatty matter comes to the top, is skimmed off, and thrown on to large cloth filters to drain. The fatty matter thus collected is known as "magma" or "sake," and the operation of treating the suds with acid is commonly known as "saking," probably a local corruption for "seeking."

This "magma" is then sent to the grease mills, while the residual liquid is run into the rivers.

The "magma" is now put into bags, which are piled up in a tank and weighted, and left for a night, when a large quantity of water is pressed out. Then the cakes of magma are placed in a hydraulic filter press kept hot by means of steam, and subjected to pressure, when a dark greasy product is pressed out, and a more solid matter is left behind in the bags. The latter is known as "sud cake," and is used as manure.

The greasy matter referred to is known as "YORKSHIRE GREASE," of which I have a few samples here.

This body is sometimes used for making soap for wool scouring, but is more frequently distilled, as will be described later on.

Yorkshire grease varies a little in appearance, but usually is of various shades of brown, sometimes almost black. It is very sticky, and easily melts, its melting point being 44° C. On treatment with soda or potash it undergoes saponification; the soap so produced is not readily soluble in water, and is of very short grain. Its specific gravity at 15·5° C. varies from 0·939 to 0·957. So far as my experiments go, the lower specific gravity is always associated with a low percentage of unsaponifiable matter.

It contains free fatty acids, unsaponifiable matter, and neutral oils, etc. The free fatty acids vary with different samples according to the character of soap or fat originally used; the unsaponifiable matter contains cholesterin, derived from the natural fat of the wool, and probably also some of the mineral oil which has been used in the wool batching. It also contains water and mineral matter.

The following table shows the composition of four samples of Yorkshire grease:

	1.	2.	3.	4.
Sp. gr. at 15·5° C.	0·9391	0·9417	....	0·9570
" " 98° C.	0·8900	0·8952	....	0·8720
	Per ct.	Per ct.	Per ct.	Per ct.
Water	0·98	1·53	1·21	0·94
Fatty acid	18·61	24·25	24·15	26·43
Neutral oil	68·62	58·25	30·02	16·86
Unsaponifiable oil	11·68	15·83	44·44	55·77
Ash	0·11	0·14	0·18	Trace.
	100·00	100·00	100·00	100·00

The fat is also used in the manufacture of lubricating greases, and it may be of interest to give its flashing point, etc.:

	°C.	°F.
Vaporizing temperature	182	359
Flashing point	220	428
Fire test	248	478

I have already mentioned that Yorkshire grease is subjected to distillation, which process I will now briefly describe.

The process of distillation is carried on in cast iron stills (wrought iron cannot be used, as it is rapidly corroded by the fatty acids), similar in shape to tar stills, and which are connected with suitable condensing arrangements.

In most works superheated steam is used along with direct heat, its use giving a larger yield of useful products and of better quality than when direct heat is used alone.

The stills are of about 1,000 gallons capacity, and will hold something like four tons of grease. When beginning the distillation, direct heat is used alone until the water in the grease has been driven off, which will take from 10 to 16 hours, after which superheated steam is run in and kept running into the still during the rest of the time.

Some kinds of grease give off a small quantity of a light "spirit oil;" others do not yield this product. After this comes the principal product, a thin limpid oil of a pale yellow color, which on cooling sets into a pale yellow grease known as "first distilled grease." This grease takes from 20 to 24 hours to come off; it is followed by a greenish oil which is collected separately and is known as "green oil" or "crude grease;" this product is usually put back into the stills with a fresh quantity of grease, or occasionally made into very crude lubricating greases.

After about 36 hours from the beginning of the distillation a thick oil begins to appear. When this occurs, the fires are drawn, and the "pitch" which is left in the still is drawn off.

The products yielded by the first distillation of Yorkshire grease are given in this table:

	Per cent.
Water and loss	20·76
Spirit oil	4·10
First distilled grease	45·54
Green oil	15·47
Pitch	14·13
	100·00

The "first distilled grease" may be treated in two ways: (*a*) it may be again distilled; or (*b*) subjected to pressure, thus yielding two products, oleine and stearine.

(*a*.) The "first distilled grease," obtained as described in the first distillation, is now put again into the stills and treated as before, when two products are obtained, "second distilled grease" and "pitch." The latter is softer than that obtained in the previous distillation, and is hence termed "soft pitch." The principal object of this second distillation is to obtain products of a better quality and purer color.

The "first distilled grease" yields about 96 per cent. of "second distilled grease" and 4 per cent. of pitch.

The "distilled greases" obtained during the first and second distillations are collected in a tank, and allowed to cool slowly, and kept at a temperature of 21° C. for some hours; by this means the stearine it contains separates out in a granular form, which facilitates the after process of pressing. A great deal depends upon the careful cooling of this grease to obtain the maximum yield of oleine with the minimum amount of damage to the press cloths. This operation of "seeding" is sometimes done in shallow metal trays, placed on racks in a slightly inclined position, the racks being in a room kept at from 21° C. to 25° C. The oleine which drains out of the stearine is generally considered to be of better quality than that obtained by pressure, and is designated No. 1 oil. The principal objection to this process is the rapid corrosion of the metal trays, while the metal dissolved in the oleine causes the discoloration of the latter.

The cooled "grease" is now put into canvas cloths, and made into cakes, which are put between the plates of a hydraulic press, where they are subjected to a pressure of about three tons to the square inch for six hours. The liquid oleine No. 2 is thus pressed out, the stearine being left behind in a solid cake.

The grease yields about 66 per cent. of oleine and 34 per cent. of stearine.

The oleine is turbid as it issues from the press, and is clarified by filtering.

The Composition and Properties of Yorkshire Grease Products.

The "spirit oil" as first obtained from the stills is pale yellow, but on keeping at the works generally becomes in time of a reddish brown color. The cause of this I will discuss presently.

It has a rather unpleasant empyreumatic odor, and is readily inflammable.

Its specific gravity at 15·5° C. is 0·794. It begins to boil at 150° C., 10 per cent. comes over under 170° C., then it distills regularly up to 240° C., when about 60 per cent. has come over; the distillation then gradually decreases in speed until about 320° C., when about 88 per cent. has come over; the temperature then rises rapidly.

It contains a small amount of free acid, equal to 4·2 per cent. of oleic acid.

Nitric acid acts only slightly on it, sulphuric acid chars it a little, while alkalies simply neutralize the small quantity of free acid it contains.

The distilled greases are of a pale yellow color, and are granular in structure. Two samples which I have examined had the following composition:

	First distilled grease.	Second distilled grease.
Water	0·98	1·04
Free acid	63·12	66·56
Unsaponifiable matter	12·88	13·24
Neutral oil, etc.	23·02	19·16
	100·00	100·00

It is interesting to note that the second distilled grease contains more free acid and unsaponifiable matter than the first distilled grease. This might be expected, since the distillation of grease must result in partial decomposition of the neutral oils it contains, leading to the formation of acid bodies and hydrocarbons. This is also shown in the analyses of the wool oils given below.

Oleine.—This, which is better known as "wool oil," comes from the press as a pale colored body, but gradually assumes a pale brown color. This coloration is undoubtedly brought about by the presence of iron in the oil derived from the press or from the tanks in which it is kept.

These oils are mostly used for oiling wool, hence their name; but they have been used for making lubricating greases and soap.

It varies very much in its composition, even from the same maker, which depends very greatly on the composition of the grease from which it is prepared.

The following table gives some analyses of several samples of wool oil:

	1.	2.	3.	4.	5.
Sp. gr. at 15·5° C.	0·9031	0·898	0·905	0·900	0·9091
" " 98° C.	0·852	0·8403	0·849	0·8434	.....
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	1·12	2·33	1·38	2·51	.....
Free acid	55·03	56·26	53·65	59·83	64·42
Unsaponifiable oil	34·66	29·46	16·32	38·92	9·95
Neutral	9·20	11·95	28·65	.....	25·63
	100·00	100·00	100·00	101·26	100 00

These figures can only be taken as approximate.

The acid is calculated as oleic acid, while probably there are other acids present, both of higher and lower molecular weight.

The flashing points of the two classes of oil differ by about 16° F.:

	Oil No. 1.	Oil No. 2.	Oil No. 3.
	° F.	° F.	° F.
Vaporizing temperature	212	203	172·5
Flashing point	338	342	328
Fire test	386	379·5	356

† From the *Journal of the Society of Chemical Industry.*

It would be advisable to reject any oil that has a lower flashing point than 330° F. for oiling wool.

Stearine.—This product is a hard, pale yellow, solid body of a greasy appearance. That obtained from first distilled grease is of a darker color than that from second distilled grease, but usually has a slightly higher melting point, and contains less fatty acids and more oil.

The following table gives the analyses of three samples of stearine:

	No. 1 second distilled.	No. 2 first distilled.	No. 3.
Sp. gr. at 15·5° C....	0·9193	0·9044	.....
" " 98° C.....	0·886	.....	....
	Per cent.	Per cent.	Per cent.
Water.....	0·6	1·48	2·85
Free acid.....	88 6	76·3	72·13
Unsaponifiable oil..	0.49	0·4	3·12
Neutral oil.....	2.11	7·7	.....
Solidifying point...	45°C. 113°F	53·5° C. / 128° F.	.....
Melting point.....	48°C. 118°F.	57°C. 134°F.	.....

The acid was calculated as stearic acid, but I am of opinion that there are acids of higher combining values present. The neutral oil given above was extracted by petroleum ether after neutralizing with alkali. There is evidently some other constituent besides those enumerated.

Stearine, when saponified with soda, gives a soap that forms an exceedingly gelatinous mass with water, and from which it is exceedingly difficult to extract with ether any free oil which may be present. It is possible to mix 25 per cent. of paraffin scale with stearin, and yet, on saponification, no separation of mineral oil will be noticed. It is this circumstance which makes wool grease stearine of so much value in making sizing tallows, which are mostly mixtures of paraffin scale and stearine. On the other hand, this gelatinizing property of stearine being probably due to the comparative insolubility of the soap it produces in water, makes it a bad article for soap making, and soap made from this stearine is noted as not making much lather.

The pitch is used for various purposes, making waterproof paper, cloth, etc.

THE RELATION OF FERTILIZERS TO FRUITS.*

By Prof. PETER T. AUSTEN, Ph.D., F.C.S., of the New Jersey State Scientific School.

THE empirical use of fertilizers is very old, perhaps as old as agriculture itself, for we have evidence that, far back in the history of the world, certain substances had been found to act beneficially on crops, and were used on the land. But scientific agriculture is a subject of very recent date, so recent, indeed, that but few seem really to appreciate how young it really is. It is evident that until the principles involved in the growth of plants were to some extent understood, there could be no real science of agriculture. It was in 1863, but twenty-six years ago, that Justus von Liebig, the great chemist, solved the deep problem which for centuries had made a science of agriculture impossible, and which no man had up to his time been able to explain. Liebig stated, as the great principle underlying plant growth, that the plant took from the soil certain substances as its food. If the supply of these substances were exhausted, the plant would die of starvation. If they were replaced, the same soil could be made to feed successive crops.

This sounds simple enough to us now, but that brilliant discovery is but little over a quarter of a century old. In 1840, Liebig first announced this principle, but he made a singular mistake, although, when we come to think of it, it was a natural enough one to make. Liebig thought that his artificial fertilizers should be added to the soil in an insoluble form, else the water would dissolve them and carry them through the soil before the plant had an opportunity to dissolve them. Experiments made by him showed, however, that his fertilizers produced no beneficial effects. On studying the matter, he found that the fertilizers must be applied in a soluble form, and that the soil had the power to retain them in varying proportions. Thus, soluble phosphates were held within a few inches of the surface, while nitrates penetrated much deeper. So in 1863 the new edition of his book appeared, and agriculture passed from empirical routine to scientific procedure.

Since this date the progress of scientific agriculture has, like all other sciences, become so rapid that it is no easy matter to follow it. It is a complex subject. It is largely chemical, but we have to study the chemistry of the plant's food, its products, the organic principles produced, the physical phenomena involved—such as the dialysis of the liquids through the walls of the cells—the mechanical condition of the soil, as well as its chemical nature, nor must we overlook the geological or mineralogical relations of the soil. Then, again, the plant is a living object, and here must study and investigate the biologist. To understand the relations of different plants to each other, the botanist must be consulted; and to protect the plant against its insect enemies, the entomologist must be called in. So each one studies that branch of science for the investigation of which his gifts and education best fit him, and each discovery is found to fit in like a brick, a cornice, or a tile in the great and massive structure which is now rising so rapidly and so symmetrically. Some discovery may seem incongruous, or incapable of application, but the thoughtful student knows that in due time it will find its appointed place, and fill it well.

* An address delivered before the New Jersey State Horticultural Society, Dec. 13, 1888.

Let no man ever disregard the value of a new truth because *he* cannot see any immediate application for it. Truth is truth, and must always come of value, soon or late. Some one asked the great Faraday what was the use and practical value of a certain remarkable discovery which he had made, but which was totally in the realm of pure science. "What is the use of a baby?" replied Faraday. So do not let us despise a new fact because *we* cannot see its value, for we are at best but too prone to be stupid, as the best of us are ready to confess, and when we see this new fact made of immense importance by the cunning of some other man, let us, when we cry out peevishly, "Why how simple! We could have done that," also add manfully, "if we had but known how to do it!"

Each man, as a rule, wishes his own interests cared for first, but fails to understand that solid progress in any one branch of agriculture requires the assistance of the whole corps of investigators. As a chemist I love to study the organic principles produced in the plant, but I need a biologist to translate the new language which I find to confront me. The geologist who studies the soil must call in the chemist to analyze it for him, and the entomologist and the botanist have repeated and lengthy consultations. Thus a well organized and trained corps of investigators is required to till well the immense field which the application of science to agriculture has opened before us.

As a result of our scientific study of agriculture, we are able to state that here, as in every other case, all must go according to law, and in accordance with the principles involved. Nature makes no exceptions. If the practice is not in accordance with the laws of nature, no matter how encouraging it may look at the start, it will fail. This may come to pass soon or late, but come it will and must. The seeds of failure will be sown at the beginning, and in due time will germinate. You all know what great progress has been made in the study of fertilizers, how the agricultural experiment stations analyze fertilizers, determine their true value, and show wherein their value lies. The agriculturist is now protected against fraud, and, if he is shrewd enough, is enabled to buy his fertilizing ingredients in the cheapest market, and make his own mixtures, thus saving in the compounding, and avoiding the application to the land of fertilizing substances that his particular soil may not need.

Soils are also analyzed, and much valuable information is thus obtained as to their composition and needs. But in horticulture more information is needed as to the effect of fertilizers on particular characteristics of the fruit. In the case of grain and fodder corps, the quality of the produce is not primarily of so much importance as its quantity. There is less limit of variation in these basic crops, but in the case of fruits, we find that not only the quantity of the crop is of importance, but also, and in a greater degree, the color, flavor, solidity, grain, etc., of the fruit. The limits of variation are much greater in the case of fruits. It is more profitable to produce a moderate crop of a fine-grained, well-colored, delicately-flavored apple than a large crop of a coarse, off-colored, and tasteless variety. The value of fruit is determined by its quality first of all. The more of such a high grade article that can be produced, the better, but no amount of a low grade fruit can compensate for its poorness.

If we study certain technical plant products, as tea, coffee, madder, indigo, dye-woods, tan barks, quinine barks, vanilla beans, we find that their value is in every instance determined by the amount of some constituent which each contains. Thus, the value of tan bark depends on the amount of tannin contained; the vanilla bean, on the amount of vanillin, and so on. In fruits, the value depends on the nature and amount of the flavoring substances, the attractiveness of the color, the consistency of the pulp, and on other qualities. By careful experimenting, it is possible to ascertain the effect of various fertilizing substances upon these valuable properties. So it has been found that the sugar beet, under scientific treatment, can be made to yield a very much larger content of sugar, and that is its valuable constituent. As a result of such experimenting, it has become possible, and practical, in Germany and France, to make the sugar beet the source of sugar supply. In our own State, the recent study made by Drs. Cook and Neale of the sorghum plant has made it possible to hope that this plant may also be made a source of sugar supply. When we come to fruits, the subject becomes more intricate, because the substances that render fruits more valuable are, in many instances, highly complicated organic compounds. The fullest development of advanced chemistry and the greatest skill of trained experimentalists are required to solve the problems involved and disentangle the complications that meet one on every side.

You are aware that all the substances about you, wood, stones, plants, water, everything, can be resolved by the chemist into some seventy primary forms of matter. These are called simple substances or elements. From these elements are built up all the different kinds of matter known to us. Thus, wood consists of carbon, a black solid, and hydrogen and oxygen, colorless gases. Salt is a compound of a blue metal, sodium, and chlorine, a green gas. When the elements unite chemically, they form new substances, which differ entirely from their constituents. In fact, a chemical change is characterized by an entire change in the identity of the substances. So fat and lye make soap, which differs entirely from either of its constituents in its properties. Gunpowder is a mere mixture of charcoal, sulpher, and niter. Water will dissolve out the niter. From the residue, benzole will dissolve out the sulphur, leaving the carbon. This is a mechanical mixture. But if a spark fall on the gunpowder, there is a flash, and the black solid disappears, it turns into gas. The change is a marked one; for certainly there is no resemblance between the smoke and gas and the original black solid. It is a real chemical change, a change in the nature or identity of the substance.

It is an easy matter to determine the composition of the organic substances that are found in plant life, but if we compare the figures representing the amounts of the constituents, we shall find that the substances are composed of carbon, hydrogen, oxygen, and nitrogen in almost every case, in some instances containing also sulphur and phosphorus. Again, we find that many of the substances are not only composed of the same constituents, but that these constituents are present in the same amounts. "How is it possible," you ask, "for two substances, entirely unlike in appearance and properties, to be composed of the same constituents, and in the same amounts?" I should despair of trying to give a clear idea of the science of organic chemistry to an unprofessional audience, for, of all sciences, it is the most bewildering in its limitless complications, permutations, and involved relations.

Let me make this illustration: Suppose you had five red bricks, ten blue bricks, and five black bricks. You could build with these all sorts of structures, designs, and figures, you could build all day long, for a life time, and yet you need never make two of them alike.

So the Creator, in his marvelously ingenious way, has fashioned a universe out of only seventy different kinds of matter, and has caused plants to elaborate in their mysterious laboratories an endless series of complicated substances, made up of but three or four different kinds of matter, but put together in all sorts of manners. It is simply bewildering, even to the trained chemist, to work out the possibilities of this stupendous invention of the Almighty mind. But, little by little, steadily and persistently, the chemist, armed with a rapidly increasing array of facts, has been able to unravel many a chemical knot, and not only to find out of what elements a substance is composed, and the amount of each constituent, but to ascertain, as well, the chemical structure, or architecture, of the substance.

It was supposed for many years that substances produced by plants and animals could not be reproduced by artificial means, and that a singular agency, called "vital force," acted in the case of living bodies, and brought about the production of the typical organic substances. Indeed, these substances were called "organic" because it was supposed that an organ of some kind was necessary for their production.

But the great chemist Wohler threw down, with a single blow, the barrier between the laboratory of the chemist and the laboratory of the plant. He made, artificially, urea, a substance which is a representative product, *par excellence*, of animal life. Through the break poured in an army of chemists, and Nature, now vanquished, turned, as the good old dame always does when fairly caught, and made lavish presents of jewels and favors to her ardent pursuers. In spite of all her quips and capricious whims, the dear old thing will take many a sparkling diadem from her broad bosom to reward the persistent attacker who will not leave her a minute's peace or quiet.

In the last years, alizarine, the coloring matter of madder; indigotine, the coloring principle of indigo; vanilline, the flavoring principle of the vanilla bean, and many other substances, have been prepared artificially in the laboratory of the chemist. To this list I might add the flavoring principles of the apple, pear, bitter almond and other similar substances. These are not imitations, but are identically the same substances, and can be made at will and in a pure state. The future awaiting chemists in this field of work is so vast that I shall not attempt to describe it.

To understand the processes of plant life, we must first of all understand the changes of matter here involved. Why is it that at one point we have starch, at another sugar, at another a flavoring substance, and at another a brilliant color? This demands extended chemical investigation of each constituent, the determination of the order in which they are formed, the relation of these substances to each other and to the functions of the plant organs. This compels a great deal of work under ground, as it were, and it is a long time before the foundations begin to appear; but when they do, the structure grows rapidly.

I should, then, advise strongly the scientific study of the effect of fertilizers on the quality of fruit as a line of inquiry distinct from their effect on its quantity, and solicit an encouragement of this work on your part. This work will require the most profound chemical science of our day, but the results will be well worth all the time, money, and energy expended upon it.

Many are the remarkable problems here involved. While you grow fruit to sell, the real object in the growth of the plant is not to furnish you with fruit, but to reproduce itself. The sexual development of the plant, as with the animal, is the primary object of its life; for if it fails to reproduce, of what value is its development? Even in the case of man, of what value is his increase in civilization, education and morality, if the race is unable to reproduce, and there be in time none to reap the benefits of the progress? In the sexual functions of the plant we meet the profoundest secrets of nature, and many of them as yet entirely baffle our skill and learning. I would counsel a concentration of our investigations on this subject, for it is the all-important function of the plant.

We know that insects are continually passing from one flower to another, and in so doing, carry off pollen from one flower and leave it on another, thus continually cross-fertilizing them. We know that the insect is attracted by colors, odors, and tastes, and, perhaps, by senses of which we know nothing, but which enable it to select one flower as more delectable than another. A plant, like an animal, demands new strains of fertilizing life, in order to keep up and improve its breed, if I may use the term. What a field opens here to the partnership of the entomologist, biologist and chemist! And how deep must we go to accomplish our purpose! In order to increase the excellence of the fruit, we must study all the chemical substances and changes involved in the plant's life, the functions of its organs, its sexual nature, the kinds and habits of the insects that visit its flowers, the particular substances and properties that attract them, even to the habits and nature of the insects. Then, knowing all of these determining conditions and causes, we will grapple with the problem bold-minded, and compel the plant to do as we wish it to do.

During the last year the chemical study of plant life has explained and illustrated many of its processes. Much solid progress has been made during the last two or three years. I will mention a few new facts as illustrations:

It is well known that fresh urine injures plant life. Hellner finds that this effect is produced by urea, which is an important constituent of fresh urine, and which, when it comes in contact with the roots, prevents the absorption of water by them, so causing the dropping off of the leaves. The discovery of new constituents in plants, or the accurate determination of the amount of

known ones, leads to new uses for them or more scientific treatment of them. Thus Kossovic finds citric acid in three varieties of cranberry, to the amount of nearly three per cent. This plant occurs largely in the north of Russia, and he proposes to use its juice for dyeing purposes, instead of the concentrated lemon-juice which Russia imports from France. Many are the peculiar changes that take place in diseased plants, and the study of these substances will be of great importance in the treatment of disease. Thus, in diseased potatoes, the amount of solanine increases, while in sound potatoes, scarcely any is found. There is also a disease of the sugar beet in which the sugar is transformed into starch.

It is now confidently stated by advanced thinkers, as a result of the recent extraordinary progress in biological discovery, that almost all disease, excepting, of course, injuries and transmitted weaknesses of organs, is preventable, since it is but the result of the attacks of lower forms of life upon us. When we know exactly what form of low life constitutes the germ of disease, we can in time find out how to attack it in our turn and destroy it. Many of the plant diseases are also caused by the attacks of lower forms of life, which grow and flourish at the expense of the plant. When we find out what these specific forms of life are, study their life histories, and determine the products of their life, we shall be in a condition to attack them, with the best hopes of success. So, then, I have no fear, speaking broadly, but still cautiously, in saying that all of these plant diseases, yellows, blights, etc., must in time yield to scientific investigation and become, not only curable, but preventable. I know the world is full of pessimistic croakers, who cannot see a line beyond their own noses, and who hence consider themselves as landmarks of the ultimate limit of scientific explanation, but the conscientious student is careful about limiting scientific progress at present. There are, of course, many things that science proves to be impossible, and such conclusive negativing proof is very valuable, and saves much useless labor in the future, but the man who grunts "It can't be done," really means "I can't do it." He can't even prove that he can't do it. Such a man does not proclaim the powerlessness of modern science, but simply proves his own personal inability and inefficiency, and that in most instances does not require any further demonstration. Strange how silly men will keep on crying out "I can't, I can't," when the world never had and never can have any reason to suppose that they could.

We should endeavor to ascertain the part played by each chemical substance in the plant, and the specific action of fertilizing materials on the formation of these substances. That they have an effect is a matter of common knowledge. Thus pigs' dung imparts a peculiar flavor to Brazilian tobacco, and some American wines taste, as it is expressed, of the soil. It is worth noting that Sambuc has found ten times as much oxide of iron in American wines as in foreign wines. How important does the chemical composition of the grape become at once to the grape grower, and how little does he, as a rule, know about it!

We should also study the relation of the different species of plants to their chemical composition, and to what extent plants of the same family produce substances of the same type. Indeed, it would be an interesting matter to make a classification of plants based upon the similarity of the substances they produce.

Another large field, but yet little trodden, is the treatment of plants with drugs, introduced into their circulation by injection, and in other ways. Marcacci soaked seeds in alkaloids and then planted them or allowed them to sprout in powdered glass. Salts of morphine hardly affected them, but strychnine, veratrine, and especially quinine and cinchonamine, did. Salts of the alkaloids have a most injurious effect on maize, beans, and lupines. On already developed plants, salts of morphine produce no effect, but strychnine, veratrine, and especially quinine and cinchonamine, are very detrimental. Strychnine hinders the development of frog spawn, but morphine and atropine favor it. A frog will be killed quickly when put into a solution of strychnine, but will live for months in a solution of morphine. Animal and vegetable protoplasm seem to act the same in relation to poisons, so that no good distinction exists between animal and plant poisons.

What a field here opens, as the effect of drugs upon plants, and the treatment of plant diseases by scientific medical treatment! By the skillful injection of certain drugs into the circulation of a plant or tree, we may be able to affect every function in their whole organisms, as we can do in the case of an animal. We may be able to cure diseases, and even to attract or repel insects, perhaps even to imitate the principle of vaccination and preventive inoculation.

In the study of the substances produced in the most highly developed organs of animals and plants, we meet strange phenomena. In the brain and spinal column of the animal, and in the yelk of eggs, a very complex phosphorized oil is found. Indeed, the presence of these phosphorized oils is an indication that the organ is, or will be, engaged in the production of nerve energy.

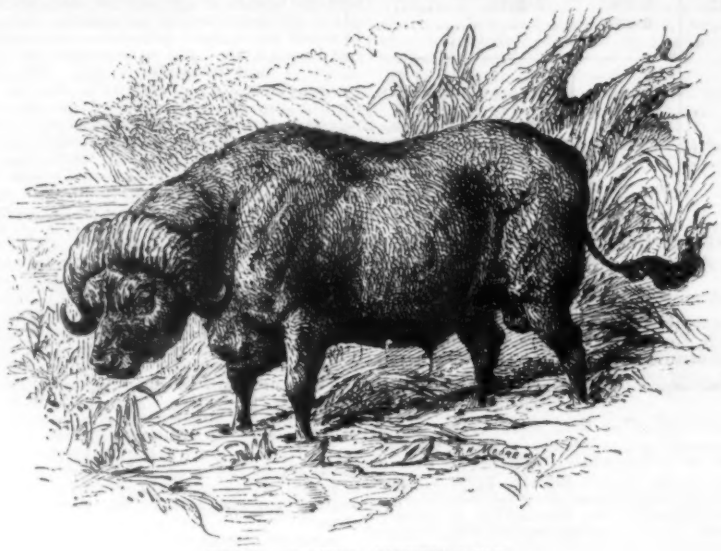
"Without phosphorus there can be no thought," runs the German saying. Now, a strange fact, indeed, has been discovered. The sugar pea has been found to contain two and a half per cent. of a brown oil containing one and a quarter per cent. of phosphorus! Other seeds have also been found to contain phosphorized oils. What can this mean? Is the plant tending toward a higher state of evolution? Does this indicate the rudiments of a nervous organization in the plant? Or is it simply the old, old mystery of sexuality and the wonder of reproduction expressed in chemical language?

In this rambling talk I have endeavored to present to you a few of the more modern views of chemists on matters pertaining to your occupation; and should I have succeeded in making clearer the great importance of a true scientific study of the problems involved in horticulture, I shall feel more than pleased.

Two hundred and fifty cherry stones and three plum kernels were found in the lower portion of the intestine of a girl twenty-two years of age, who died recently in the Friedrichsheim City Hospital in Berlin.

THE CAPE BUFFALO.

THE African buffalo has often been declared to be the most dangerous wild beast of that continent for a hunter to encounter in conflict—more formidable than either the elephant or the lion. The "Bos Caffer," or Cape buffalo, attains a great size, often weighing nearly fifty stones, and has speed as well as enormous strength. Its color is deep brown or black; it has a pendent dewlap, and its large black horns are terrific weapons extending to the right and left of the head, and turning upward to sharp points, which are nearly 5 ft. apart. Any man or beast once caught between these horns is sure to be killed; even the lion is thus gored to death, while his teeth and claws make no impression on the thick plates of bone and horn that shield the buffalo's forehead. Herds of five or six hundred buffaloes together roam over the plains of South Africa, and cannot be easily or safely approached. The true buffalo of South and East Africa is a very different animal from that which is called the buffalo on the prairies of North America, which is really the bison, a slow and stupid creature.—*Illustrated London News.*



THE CAPE BUFFALO.

THE SUBTERRANEAN WATER OF THE OUED RIR'.

THE region of the Oued Rir', of which Tougourt is the capital, is situated in the Saharan plains that extend to the great chain of the Aures Mountains in the province of Constantine. It is one of the countries of Africa most plentifully supplied with subterranean water—a sort of Egypt on a small scale, with a subterranean Nile. Properly speaking, the Oued Rir' is a valley that descends from the south to the north and ends to the southwest of the Chott Meirir. The minor bed of this valley is represented by a zone of levels, *chotts* and *sebkhas*, along which lies a series of prosperous oases. The oases of the Oued Rir' begin, at the north, at Ourir, situated 60 miles to the south of Biskra, and succeed one another for 78 miles toward the south. The existence of this series of oases is connected with the presence of a great reservoir of subterranean water under high pressure, which may be made to spout to the surface through sufficiently deep wells. Numerous spouting wells, some of them sunk by the natives and lined with wood, and others by the French ground auger, and tubed with iron, tap this subterranean reservoir, which extends continuously all along the Oued Rir'.

The water comes from a depth of from 230 to 250 ft. beneath the surface and has an average temperature of 25·1°. It lies in the center of a very permeable mass of sand, but is covered and kept under pressure by an impermeable layer of marl and sandy marl with gypsum, which the borings have to pass through. As soon as the tool has pierced the covering, that is to say, the stratum which immedately covers the water, and which is sometimes very hard, the compressed water makes an eruption into the bore hole and spurts to the orifice of the metallic column—the first jet often spouting to a height of several yards. For a few days, the water carries along much sand and many pebbles and even large blocks, which it vomits to the surface. Then a steady flow gradually sets up, and the water, issuing clear and limpid from the orifice, falls back around the tube like a transparent dome of crystal glass.

Fig. 1 gives a view of well No. 4 of the indigenous oasis of Sidi Amran. This is the king of the wells of the Oued Rir'. It discharges 1,500 gallons per minute—a true river. It was driven in 1884, and is called *Ain Jus* (Jus fountain), from the name of the well known engineer who directed the borings of the Oued Rir' from the beginning up to recent years. Fig. 2 represents well No. 3 of the indigenous oasis of Sidi Sliman (Ain Lieutenant Bourot), sunk in 1887 by Sub-lieutenant Clottu, the present superintendent of the military boring works of the Oued Rir'. This well discharges 1,000 gallons of water per minute—as much as the finest artesian well of Paris, that of Passy. Such discharges are not rare in the Oued Rir', and 750 and 1,000 gallon wells are even quite numerous there.

In places, the water under pressure has cut a passage for itself through the overlying earth and has given rise to natural wells, at the points of emergence of which are found cavities, generally deep, and butts comparable to the waters of small water volcanoes. Such is the origin of many of the lakes called *behour* (plural of *bahr*, "sea") and of almost all the small reservoirs called *chria* ("nest") met with on the surface of the Oued Rir'. Fig. 4 gives a geological section of one of the most characteristic chrias of the Oued Rir', the *Chria Ayata*. As for the behour, these are sometimes large lakes with blue and limpid water, which one is surprised to meet with on the surface of these parched regions. The *Bahr Merdjedja*, near Tougourt, is no less than 1¼ miles in length. It must be stated that some of these behour are due to the caving in of old groups of native wells. In fact, these wells, dug by hand by the natives, have walls that are simply timbered, and, at the end of a certain time, they cave in and fill with sand. Their duration is therefore fortuitous. On the contrary, the French wells, sunk by means of the European boring apparatus, and tubed with iron, last, so to speak, indefinitely, when they have been properly driven and their tubing rests upon a solid stratum. The fact is that the majority of the French wells of the Oued Rir' have not varied in their discharge since they were put down, and certain of them now date back to more than thirty years.

Fig. 5 shows how numerous the behour, chrias, and wells are in certain regions of the Oued Rir'. It represents the region of Ourlana, situated in the center of the Oued Rir', and everywhere perforated, like a skimmer, with bore holes, natural springs, and old wells. And yet, as a general rule, in this region, the new borings have not caused any decrease in the discharge of the already existing wells, although the distance may not have been at times but half a mile, and even less. It must be said that this part of the Oued Rir' is the one best provided for as regards both the volume and pressure of the underlying water.

The behour and the chrias of the Oued Rir' are in-

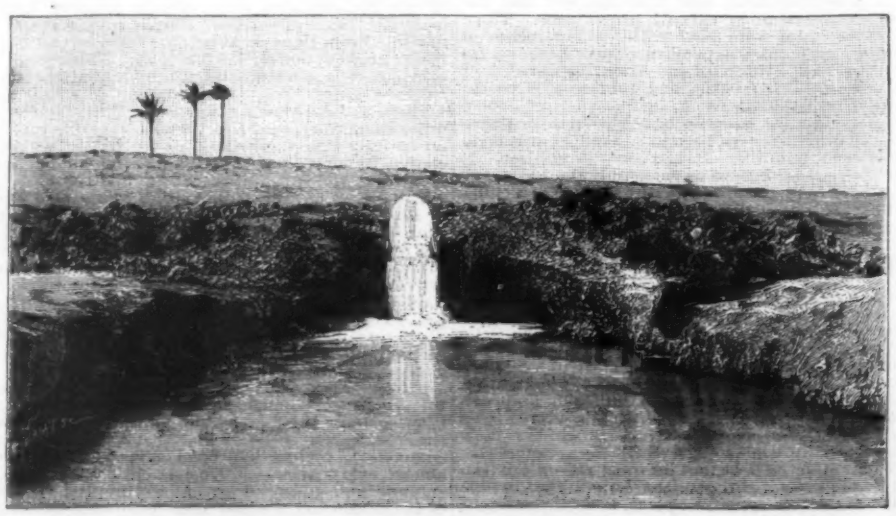


FIG. 1.—JUS WELL AT SIDI AMRAN.

habited by small fish and by mollusks which live in their waters and breed in them under normal conditions. There are also met with therein crabs belonging to a terrestrial or, rather, an amphibian species (Fig. 3). It is a curious fact, which has been called in question, but the truth of which we can authenticate, that cer-

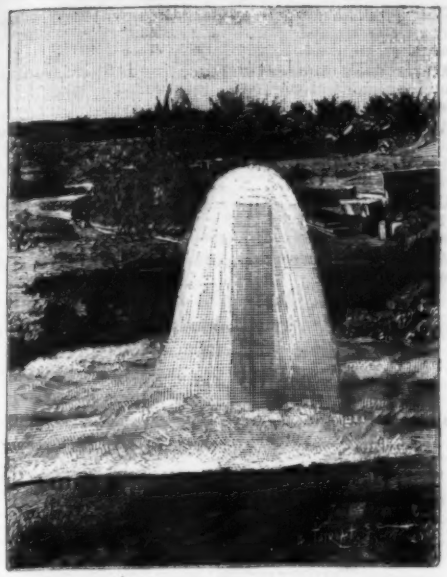


FIG. 2.—BOUROT WELL AT SIDI SLIMAN.

tain spouting wells of the Oued Rir' have thrown out, and are still throwing out, living animals, such as crabs and mollusks, like those living on the surface. The fact is beyond doubt, and it remains to explain it. For our part, we have never believed that these animals were subterranean and that their normal dwelling place was in the depths—a theory against which objections would be urged in great number in the present case. Whence do they come, where do they develop? Why are they not blind? The simplest and most sensible explanation is the following: The subterranean reservoir of water has, so to speak, vents at the surface, not only by direct way of the wells, but also through the complex network of natural conduits that end in the behour and chrias. Moreover, there are natural cavities in the water-bearing strata, and, as a consequence of the strong suction of the ascensional column, there are large chambers produced at the bottom of the bore holes, and a converging network of small channels all around. It will be understood, then, that there may be a subterraneous communication between the behour and the chrias and between them and the wells, and hence it is easy to imagine that the fish sometimes undertake trips from one bahr to another, and that when they are swimming in the vicinity of a well they yield to the suction created by the ascending water, and are thus carried suddenly to the surface.

If we take a glance at a detailed map of the Oued Rir', we shall at once see that the behour and the chrias, the exhausted or active native wells, and the French wells, along with the oases themselves, far from being distributed indifferently over the surface of this large plain, are grouped and arranged on the east side of the valley, along the zone of the surface levels. In fact, it is on this side that the subterranean water exhibits its maximum of volume of pressure, while toward the west it disappears quite abruptly. It is not a question here, then, of an ordinary or regular reservoir of a width comparable with its length, but rather of a water-bearing zone, elongated from the north to the south, and limited at the sides. It is a sort of river, a subterranean artery, rather. These words, however, should not allow us to imagine a rapid flow. The subterranean water is assuredly not stagnant, nor confined in a closed reservoir, and motionless, for that would be contrary to the ordinary laws of nature. It, in fact, has a real and continuous flow between its feeders and the points where it emerges, but the flow is a general one, of imperceptible velocity, save in the immediate vicinity of certain points of entrance and exit.

On another hand, the course of the subterranean water of the Oued Rir' is far from being as simple as that of a river in a valley, but is of a most capricious character. One subterranean artery meanders with a thousand sinuosities under the uniform superstratum. It varies from 2½ to 8½ miles in width, and it is not always continuous, for, in the region of Ourlana, for example, it divides in two to the north and south, so as to form an irregular X. Finally, it would be erroneous to imagine it a river occupying a hollow channel and limited by banks. The subterranean water, on the contrary, filters through a continuous mass of permeable sand. Laterally, the liquid zone is not isolated; it is situated in the midst of a network of underground springs and of secondary deposits in large numbers. Now, just as the arteries carry the blood from the heart to every part of the body, just so the subterranean water of the Oued Rir', continuously augmented subterraneously, keeps forcing its surplus into the permeable portions of the surrounding earth, wherein it spreads, disperses, rises to the surface, and finally evaporates.

The boring operations of the Oued Rir' were inaugurated in 1856, two years after the conquest of the country by the French troops. Since then, they have been carried on with perseverance by the military administration under the as skillful as devoted direction of Mr. Jus. On October 1, 1885, the Oued Rir' had 114 French spouting wells and 492 native ones, and all of these united (including a few natural springs) were discharging 68,900 gallons per minute, say 1,065 per second. It is difficult to imagine such a volume of water emerging in the open Sahara, in "the land of thirst." We have here, in fact, a truly immense discharge, equal to about a tenth of the flow of the Seine at low water, or to that of watercourses important enough to have given their names to departments, such as Cher and Indre. Moreover, the Oued Rir' belongs to what, in a general way, may be called the lower Sahara. It is that part of the Sahara that extends to the south of the province of Constantine of the regency of Tunis. Now, in a general manner, the lower Sahara is an immense basin of subterranean waters.

A few privileged regions especially attract attention. To the north of the Sahara of Constantine, in the region of Biskra and to the west thereof, are the forty-two springs or groups of springs of the Zab, which together discharge more than 660 gallons of water per second. To the south, in the Oued Rir', there are hundreds of artesian wells, whose total discharge, as we have just said, is 1,065 gallons per second. More to the south, in the region of Ouargla, again, there are numerous artesian wells whose total discharge approaches 265 gallons per second. On another hand, in the Tunisian Sahara, we have the magnificent sources of the Djerid, to the east; the small sources of Nefzaoua, to the south; the large sources of the littoral region of Gabes, to the east; and the celebrated sources of Gafsa, to the north.

This is not all. Far from it. In addition to these defined regions, toward which the subterranean water flows, there exists, over the whole extent of the lower Algerian and Tunisian Sahara, a diffusion of subterranean water which impregnates the mass of permeable earth and sand as if it was an immense sponge. Everywhere, or nearly everywhere, there exists an ascending stream of feeble flow which rises nearly to the surface through pressure and capillarity, and which, flowing in the depressions in the earth, feeds the sebkhas and chotts. Everywhere in the Saharan climate an active evaporation takes place at the expense of this upper volume, and the amount of water lost in this way on all sides is incomparably greater than the volume discharged by all the sources and all the spouting wells combined of the lower Sahara.

But whence comes all this water that is contained in the subsoil of regions where rain is a rare and exceptional phenomenon? Whence does it come, and how is this basin fed? In a few words, the subterranean water of the Algerian and Tunisian lower Sahara comes in a great part from the north (contrary to the most widespread opinion), and descends from the Atlas chain of mountains. The supply is maintained chiefly in two ways: first, through the atmospheric water absorbed by the alluvial soil of the lower Sahara, and second through the subterranean water divided from the cretaceous formation of the Atlas Mountains. There are, in the first place, the rain water and the running water

FIG. 4.—CHRIA AYATA.

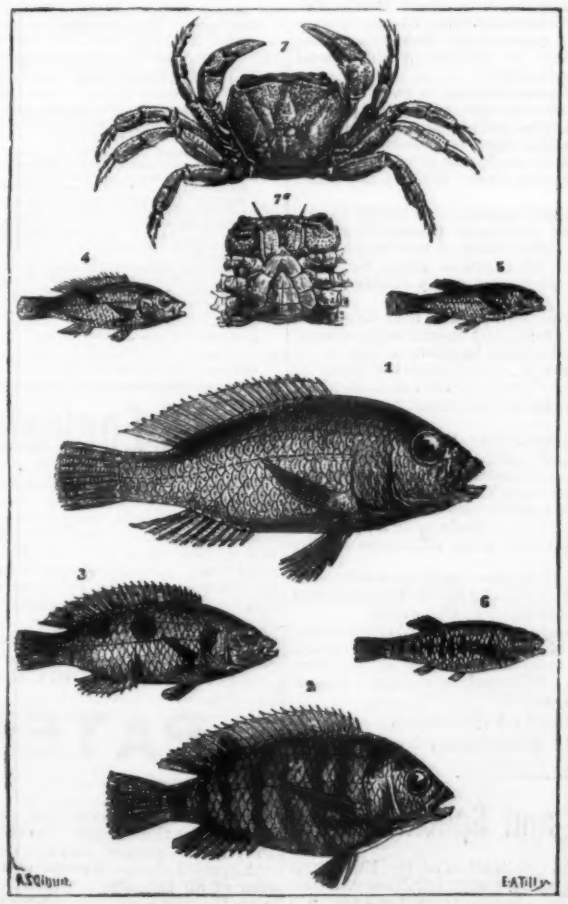


FIG. 3.—FISHES AND CRUSTACEANS FROM THE SUBTERRANEAN WATER OF THE OUED RIR'.

1. Chromis desfontainei. 2. Ch. zilii. 3. Hemichromis saharæ. 4. H. rollandi. 5 and 6. Cyprinodon calaritanus. 7. Telphusa fluviatilis.

FIG. 5.—SPOUTING WELLS, CHRIAS, AND BEHOUR OF THE OURLANA REGION.

of the valleys, which infilter in part into the permeable earth of the lower Sahara, either directly or through the intermedium of great sand dunes, and descend through gravity, and thus acquire pressure and become capable of spouting forth in the interior of the basin. Now as regards this, the first source of supply, the largest portion is furnished by the rivers that descend from the mountains of the north—Oued Djeddi, Oued Biskra, Oued el Arab, Oued Tarfaoui—which, after the rains of winter and the melting of the snow in spring, rise to a considerable height and flow in a torrent. In the second place, the waters annually furnished by the snow and rain that fall upon the mountains of the north, whose altitudes reach 7,500 ft. in the Aures, infilter themselves in part into these mountain masses and are absorbed by the permeable strata that they meet there. In this way, in the Atlas Mountains, there originate numerous deposits of water, which circulate subterraneously, and flow, with increasing pressure, toward the earth, to reappear in the lower Sahara at a level 6,000 ft. below the place of origin, and where they either come directly to the surface, as at the Zab, or

flow under a certain thickness of earth, through which they afterward rise, as in the interior of the basin.—*La Nature.*

OPENING OF A PYRAMID.

MR. W. M. FLINDERS PETRIE has at last accomplished the difficult task which he began last season. He has, says a letter to the London *Times*, succeeded in forcing an entrance into the sepulchral chamber of the pyramid of Amenemhat III., at Hawara, in the Fayum. In our last report of Mr. Petrie's work we related how he had tunneled a passage from the north face of the pyramid as far as the stone casing of the central chamber, which proved to be enormously massive, and resisted all his efforts. The summer was then so far advanced and the heat had become so overwhelming that he found himself compelled, very reluctantly, to postpone the completion of his operations till the winter.

Returning to Egypt in November last, Mr. Petrie at one went back to Hawara and began by making trial excavations at various points round the base of the pyramid in the hope of discovering the original entrance. Failing in these attempts, he decided to call in the assistance of skilled masons from Cairo and quarry down through the roof of the central chamber, which he had already reached last season. The fact that the roof is 15 feet thick and that it has taken Mr. Petrie's masons some three weeks to cut a very small vertical shaft through it gives some notion of the massiveness of the structure.

Once in, the secret of the true entrance passage was disclosed, and the explorer was free to track the path by which he might have made his way into the central chamber, had he but succeeded in finding the point from which it started. That point proves to be outside the pyramid, and apparently some distance from it; so that the tomb of the founder may have been entered from the adjoining labyrinth, the site of which was identified last year by Mr. Petrie. This may, in fact, be what Herodotus intended to convey when he said: "At the corner of the labyrinth stands a pyramid 40 fathoms high, with large figures engraved on it, which is entered by a subterranean passage" (Book II., chapter 148). Entry from a distance, by means of a subterranean passage, is a novelty in construction, and has no precedent in any of the Ghizeh pyramids (fourth dynasty), nor yet in those of the sixth dynasty, of which so many were recently opened at Sakkarah.

This, indeed, is the first time that the plan of a royal tomb of the twelth dynasty has been laid open, and it differs very considerably from the plan observed by the architects of the ancient empire. The Great Pyramid and all the other pyramids of the Ghizeh group, the pyramid of Meydum, and the Sakkarah pyramids, have the entrance passage in the center of the north face of the structure and at some height from the level of the desert; but the pyramid of Amenemhat III. is entered from the south side, and by an opening not in the middle of the side, but at about one-fourth of the distance from the southwest corner. It is here that the subterranean passage, from whatsoever point conducted, strikes the south face of the structure. The ups and downs of the passages in the earlier pyramids are not so many, and the obstacles placed in the way of possible intruders consist chiefly of a series of massive granite portcullises, let down from above, after the mummy had been deposited in its last resting place; but the defenses of the pyramid of Amenemhat III. are of a different kind, and more nearly resemble the baffling turns and windings and wells of the rock-cut sepulcher of Seti I. at Thebes. It marks, in fact, the transition from the Memphite to the Theban style of sepulture.

"The passage," says Mr. Petrie, "does not run straight into the chamber, but slopes down northward for some distance. Then a branch passage leads eastward, the main line continuing on as a blind. The branch passage (still going eastward) ends blank, but the issue from it is by a large trap door in the roof. This trap door opens into an upper passage leading north, which presently turns off to the west. Here it again ends blank, and another roof trap gives access to another upper passage running further west. This passage ends in a well leading to a short passage southward, which ends in another well, now full of water. This well, I imagine, must lead to another short passage going eastward, whence a last well would ascend into the chamber."

The pyramid, as Mr. Petrie feared and expected, had been broken into and plundered long ago, probably in the time of the Persian rule in Egypt. A forced entrance had been made from the second roof trap into the sepulchral chamber, and anything of portable value which that chamber contained has of course disappeared. The chamber itself, which is three feet deep in water, is all but monolithic, the floor and the four sides up to a height of six feet (inside measurement) being hollowed out of a single block of sandstone. The dimensions of the chamber are 22 feet long by 8 feet wide inside, and Mr. Petrie estimates the weight of the block as from 100 to 200 tons. One course of stone all around supports the roofing slabs, of which there are but three.

This chamber contains one large and one smaller sarcophagus of polished sandstone, both perfectly plain and without inscriptions. A projecting plinth decorated with paneled ornaments runs around the base of the large sarcophagus. The second sarcophagus has been contrived by the insertion of a head and a foot slab between the large one and the wall; and this has been closed over by a narrow lid. There were also two boxes of polished limestone in the chamber, decorated round the base with the same paneling as the large sarcophagus. One of these is broken up. A similar kind of stone box, it may be remembered, was found in the pyramid of Pepi-Merira (sixth dynasty), which was opened some eight or nine years ago. Some fragments of alabaster vessels have been recovered from the water in the chamber; but these, like the sarcophagi and the boxes, are uninscribed, with the exception of one fragment of an alabaster vase, which bears the name of Amenemhat III.

The walls also, as far as Mr. Petrie has been able to examine them, are quite plain, thus differing from the pyramids of Unas, Pepi, and Teta of the fifth and sixth dynasties, which are lined with religious texts of great value and interest. That the great sarcophagus is the sarcophagus of Amenemhat III., and that the pyramid is his pyramid, admits, however, of no shadow of doubt. In the ruins of the last two temples adjoining the pyramid Mr. Petrie last year found fragments of inscriptions, in which the names and titles of this king repeatedly occurred, to say nothing of classic tradition, which has consistently assigned the "at the corner of the labyrinth" to the royal builder of that famous structure. But for whom was the second and smaller sarcophagus constructed?

Mr. Petrie suggests that it may have been for Amenemhat IV., who was for several years associated with his father upon the throne; or for Queen Sebakneferu, who succeeded her brother Amenemhat IV. Either conjecture is probable; but remembering that Diodorus attributes one of the Hawara colossi to Amenemhat III. and the other to his queen, and that he further states how the revenues derived from the fisheries of Lake Mœris were assigned to this royal lady "for her perfumes and her toilet," we were tempted to inquire whether a wife so honored as this tradition implies would not have been the more likely occupant of the lesser sarcophagus.

Simultaneously with his work on the pyramid, Mr. Petrie has also been continuing his excavations in the neighboring cemetery, where he has found many large tombs of the twelfth dynasty and a few inscriptions of that period. Besides the usual yield of amulets, beads, etc., he has also found three large and quite perfect Greek deeds of the Christian period, beautifully written on papyrus, and a few more mummies of the same types as those exhibited last summer in the Egyptian Hall, Piccadilly, with panel portraits laid over the faces of the dead. Mr. Petrie will probably next attack the pyramid of Illahun, which, it is supposed, has never been opened. It is, however, very unlikely that any pyramid has escaped being plundered by either the Persian, Roman, or Arab conquerors of ancient times.

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TABLE OF CONTENTS.

PAGE

I. AGRICULTURE.—The Relation of Fertilizers to Fruits.—By Prof. PETER T. AUSTEN.—A recent paper read before the New Jersey State Horticultural Society, giving a scientific view of the possibility of the future in the development of scientific fruit fertilizers 11171

II. BIOGRAPHY.—Zenobe Gramme.—The inventor of the Gramme dynamo-electric machine, a wonderful instance of the development of scientific genius at a late age, his portrait.—1 illustration. 11167

III. CHEMISTRY.—Gymnemic Acid.—By DAVID HOOPER.—A very interesting investigation of the curious substance that possesses the property of destroying the taste of bitter or sweet substances, with analysis. 11170

Yorkshire Grease.—By GEORGE H. HURST.—A very interesting investigation of the fatty products from the washing of wool, with numerous tables of analyses and the composition and properties of products derived from the grease. 11170

IV. CIVIL ENGINEERING.—Improved Steam Inspection Car.—The Ionia steam inspection car, for use of the inspectors and others interested in the condition of the permanent way of railroads.—Details of its use and characteristic features of its construction.—2 illustrations. 11163

Plant and Material of the Panama Canal.—By WILLIAM PLUMB WILLIAMS, Jr.—The commencement of an elaborate paper on the machinery used in the great engineering operations on the Isthmus, with illustrations of the dredges devised by engineers of different nationalities.—6 illustrations. 11159

Rapid Transit for Chicago.—A review of the future necessities of the great Western metropolis, with suggestions for an improved construction of rapid transit line adapted for the probable developments of the next century.—2 illustrations. 11161

V. ELECTRICITY.—Electric Wiring of Buildings.—By J. D. F. ANDREWS.—A very excellent and practical paper on this subject, giving details of the method of correctly preparing buildings for electric light installations.—5 illustrations. 11167

Electric Light at the Paris Exhibition.—Note of a paper by M. Hippolyte Fontaine on the titular subject, accompanied by tables of the lights to be employed, the contractors therefor, and the plan and elevation of machinery hall, showing the disposition of lamps.—2 illustrations. 11169

VI. EXPLORATION.—Opening of a Pyramid.—The account of an interesting Egyptian find.—A subterranean entrance to a pyramid recently discovered.—Its nearly monolithic chamber and contents 11174

The Subterranean Water of the Oued Rir'.—A full account of the artesian wells of the Saharan Oasis, with details of the fishes and crustaceans found there, and map of the Ouriana region.—5 illustrations. 11172

VII. METALLURGY.—A Miniature Steel Works.—A Hindostanee steel works, with full details of the method of working.—A curious instance of native skill and industry. 11167

VIII. PHOTOGRAPHY.—The Development of Gelatino-Bromide Lantern Plates.—A recent communication to the Manchester Photographic Society, giving numerous formulæ of different developers. 11165

IX. PHYSICS.—A New Photometer.—An efficient and simple substitute for the Bunsen photometer disk, involving a combination of two prisms—2 illustrations. 11169

X. TECHNOLOGY.—Improved Sectional Warping Machine.—Description and illustration of a new machine recently constructed in England for warping.—1 illustration. 11165

Improved Wood Pulp Digester.—Description and illustration of a digester of the latest design, with lead lining for sulphite liquor treatment of timber.—1 illustration. 11166

New Apparatus for the Concentration of Extracts in Vacuo.—By L. A. ADRIAN.—A recent improvement in pharmaceutical technology for the preparation of extracts on the large scale.—2 illustrations. 11165

Ramie or Rhea Fiber Cleaning Machinery.—An attempt at solving the problem of preparing these fibers.—A recent machine invented by Mr. Wallace, of Belfast, originally intended for flax, and its proposed application to the new fibers.—2 illustrations. 11164

The Wells Light.—A new creosote oil burning blast lamp for use in out-of-door operations for light-giving purposes and for the production of heat.—2 illustrations. 11165

XI. ZOOLOGY.—The Cape Buffalo.—Note and illustration of this animal, one of the most dangerous of the Bos tribe.—1 illustration. 11172

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